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CONTRIBUTION TO THE THEORY AND PRACTICE OF TONOMETRY*

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General Introduction
I. Theory
A. Introduction
B. Coefficient of ocular rigidity
C. First approximation
D. Second approximation
1. Relation of tonometer readings to pressure
2. Numerical value of the constants
3. Volume of indentation
4. The initial intraocular pressure
II. Practice
A. Method
1. Instrument used
2. Method of measurement
B. Pressure
1. Normal range of pressure
2. Errors of measurement
C. Rigidity
1. Relation of age to rigidity
2. Axial refraction
3. Corneal curvature
4. Normal range of rigidity
5. Physiological cupping of optic disc
6. Corrected Schiötz nomogram
7. Uveitis
8. Glaucoma
D. Standardization of tonometers
III. Summary and Conclusions

"Das Tonometer in seiner jetzigen Gestaltung ist noch weit davon entfernt, so genaue Angaben geben zu können, dass man es als mathematisches Instrument betrachten könne; dagegen genügt es vollkommen zu seiner practischen und rein klinischen Bestimmung."—Dor, 1868.[1] †

Two generations of ophthalmologists have passed by since Dor, in discussing one of the earliest models of a tonometer, wrote the judgment quoted above, and still the essential validity of his conclusion can hardly be questioned. It is true that during this period approximately 50 different forms of this instrument have been devised, and that within the last 30 years the form invented by Schiötz has been generally adopted as the most useful one. No doubt, also, our requirements for clinical exactness have been greatly raised and we would no longer be satisfied with the crude model with which Dor worked. Nevertheless, we have, even now, very little exact knowledge as to what, precisely, we are measuring when we use the tonometer, nor do we know what interpretation to give to the divergent readings obtained with different types of instruments. That this defect in our knowledge is well recognized may be seen from the fact that at the International Congress in Amsterdam, in 1929, a commission was appointed to standardize tonometers. Recent efforts by Vogelsang[3] and others to devise ballistic methods for the measurement of ocular elasticity point in the same direction. The need for a thorough review of the theory and practice of tonometry is, therefore, evident.

In the present study, we have not attempted a complete review of all the fac-

* From The Wilmer Ophthalmological Institute of the Johns Hopkins University and Hospital.

† Quoted by Lloyd.[2]

tors that enter into a tonometric reading, but have set forward the much more modest goal of attempting to analyze and to measure to a first approximation what influence is exerted upon the tonometer reading by the variations in the structural rigidity of the eyeball. When a tonometer of the Schiötz type rests on the cornea, the cornea is indented and the eyeball deformed. The degree of indentation measured in reading the instrument is dependent, not only upon the pressure that existed within the eye before the tonometer was applied, but also upon the degree of resistance that the coats of the eye exhibit to the deforming force of the tonometer weight. Our purpose has been to obtain, if possible, some measure of this resistance to deformation and some indication of the appropriate corrections in pressure readings which variations in resistance of this type should dictate.

The general plan of our study may be outlined as follows: We have first attempted a theoretical analysis of the factors involved in a tonometric reading and have grouped together for consideration those factors other than pressure which may be thought of as contributing to the resistance that the eyeball exhibits to indentation by the tonometer. Previous studies on the elasticity of the eye are then considered, and from the experimental data recorded by other observers a mathematical law is derived of the relation between volume and pressure changes in the eye, together with a mathematical formulation of what may be regarded as the coefficient of rigidity of an eyeball independent of pressure. This law is then applied to tonometric readings on the assumption that the application of the tonometer with successively different weights to an eye produces in the eye successively different pressure and volume changes. In order to accomplish this it is necessary to know the volume of the corneal indentation produced by the tonometer plunger and the intraocular pressure at the time when the tonometer is resting on the eye. The latter can be computed directly from the data given by Schiötz in the original measurements which he made in order to calibrate his tonometer. The former may be calculated to a fair approximation, as will be shown below. It follows that with the aid of these calculations the coefficient of rigidity of an eye can be computed from a pair of tonometric measurements made with two different weights. By allowing for the distortion of the cornea produced by the tonometer foot plate, the intraocular pressure that existed before the application of the tonometer on the eye may be estimated. A chart or nomogram has been constructed with the aid of which these otherwise laborious calculations can be performed graphically.

The second stage of the investigation has consisted in applying these methods for the measurement of the rigidity and pressure first to normal and then to abnormal eyes. A statistical analysis of the results on normal eyes has enabled us to evaluate the effect of age, sex, axial refraction, and corneal curvature on intraocular pressure and ocular rigidity as determined by this method. The average normal ocular rigidity is found to be somewhat lower than that implied in the data used by Schiötz to calibrate his tonometer, and the average normal intraocular pressure is found to be correspondingly higher than that assumed by Schiötz. Using these data, a correction for the Schiötz chart or nomogram is obtained. Finally, the results of measurements of ocular rigidity and pressure in certain diseases are presented, and also an analysis of the effect of certain drugs on the rigidity and pressure of the eye.

I. Theory

A. Introduction

When the Schiötz tonometer is placed upon the eye, a twofold effect is produced. The foot plate of the tonometer has a radius of curvature of 15 mm., while the radius of curvature of the cornea in normal eyes varies from 7 to 8 mm. Consequently, the cornea must be flattened over the area of contact with the tonometer. In addition, the plunger of the tonometer indents the cornea, and it is the depth of this indentation from the level of the tonometer foot plate that is read on the tonometer scale. Since only this second effect is directly measured, it seems desirable to concentrate our attention first upon this effect alone, and to deal with the first effect as a correction to any results obtained from the analysis of the second.

The shape of the indentation produced by the plunger is unknown, but it must depend to a marked degree upon the shape of the plunger. We have, therefore, in this paper, confined our attention to the Schiötz plunger in its original form with concave end of the same radius of curvature as the tonometer foot plate, and have omitted all consideration of the rounded plunger of the Schiötz X tonometer or the McLean tonometer. The advantages of limiting ourselves to this type of plunger are, first, that more extensive experimental and clinical data exist with this type, and second, that the theoretical development of the relations which we seek are simpler when this form is considered.

When the plunger indents the cornea, fluid is displaced from beneath it, and the intraocular pressure is raised. Part of the displaced fluid may be accounted for by an expulsion of blood from the intraocular vascular bed and an actual absorption of fluid out of the ocular cavity, while the remainder can be accommodated only by a distortion of the eyeball as a whole, no doubt mainly by an expansion in the equatorial zone of the eye. The relative importance of these three factors may be evaluated as follows: Clark[4] and Ridley[5] have measured the changes in pressure in the eye associated with measured changes in the total volume of the intraocular contents in living animals, and again immediately after the animals had been killed by exsanguination, and have found the coefficient of elasticity of the eyeball unchanged under these circumstances. It is clear, therefore, that, within the clinically attainable range of pressure, the displacement of blood produced by sudden small variations in intraocular pressure is either negligible in volume or may be included without sensible error in the general elastic coefficient of the eyeball. It will be shown below that in conditions of marked dilatation or constriction of the intraocular vessels appreciable changes in ocular elasticity can be demonstrated.

The second factor, namely, the actual expulsion of fluid from the ocular cavity, cannot be instantaneous, and may be reduced to a minimum by reducing the time of the tonometer reading to as short a period as possible. This factor has been especially studied by Wegner[6] in his "Belastung" experiment, and can be measured if the tonometer is allowed to rest upon the cornea for an appreciable period. If the tonometric measurement is done rapidly, it can be repeated within a few seconds and the second reading will not be found to indicate a significantly lower tension than the first. By using rapid duplicate measurements, the error resulting from this factor may, therefore, not only be reduced to a minimum, but its actual magnitude may be read in each case.

We conclude, therefore, that a measure of the compressibility of the intraocular

vascular bed is included in the elasticity measurement, while, on the other hand, the expulsion of intraocular fluid from the interior of the eye, as the result of the massaging effect of the tonometer, does not introduce important errors into the measurement.

The tonometer plunger indents the cornea in virtue of its weight, and must cornea is equal to the downward force exerted upon its base by the distorted

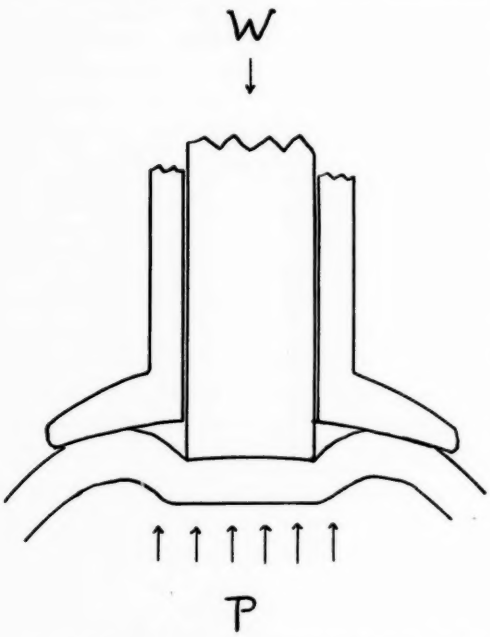

Fig. 1 (Friedenwald). Maklakoff and Fick's law: $W = P \times A$.

cornea is equal to the downward force exerted by the weight of the plunger plus that of the lever arm which rests upon it (fig. 1). Their combined weight is that which in the Schiötz tonometer is signified by the weights placed on the plunger. The upward force resisting this consists in two factors. There is, first, the force of the intraocular pressure that is exerted over the whole area of the indentation. It must be remembered that the pressure here referred to is not the intraocular pressure before the tonometer was applied, but the actual pressure existing when the eye is carrying the tonometer and its plunger. The second factor in the upward force is that derived from the elastic stress in the deformed cornea itself. A few experiments with freshly excised corneas of animals and man suffice to show that the cornea is normally extremely pliable and that the elastic stress introduced by the indentation of the cornea is very small indeed, amounting, in fact, to only a few milligrams. Furthermore, since variations in the elasticity of the cornea will produce effects on the tonometer readings in the same sense as the variations in the elasticity of the eye as a whole, there is no need, in the present state of our study, to make any special allowance for this factor.

Omitting, therefore, the factor of corneal elasticity, we conclude that to a close approximation the formula first suggested by Maklakoff[7] and Fick,[8] and later supported by Schiötz, is correct:

$$W = PA \qquad (1)$$

in which W represents the weight of the plunger and lever arm; P, the intraocular pressure measured in grams per square millimeter; and A, the area in square millimeters of the indentation. It is plain that if we knew the shape of the indentation, we could calculate both its volume and area and that, by using two different weights successively, we could produce two different measurable changes in pressure and in the shape of the eyeball.

Before tackling the rather complex problem of the shape of the indentation produced by the tonometer plunger, we must ask the more elementary question: Is it possible from two or more sets of observations regarding the pressure and volume changes in an eye to calculate a coefficient of the elasticity or rigidity of the eyeball as a whole?

B. THE COEFFICIENT OF OCULAR RIGIDITY

The first attempts to study the rigidity of the eye were made by Weber[9] in 1887. There is no need to review in detail the early contributions to this subject which have recently been very competently discussed by Vogelsang.[3] The studies which are of value in our present problem are those by Schultén,[10] Koster,[11] Schiötz,[12] Ridley,[5] and Clark.[4] These five authors have each reported the results of experiments on the distensibility of the eyeball. The technique of these experiments was simple: The interior of the eye was connected by a cannula with a reservoir of salt solution that could be raised or lowered. As the reservoir was raised, the eyeball became distended and the volume of fluid entering the eye could be measured. The authors report on the change in volume of the eye correlated with each successive change in pressure. The experiments have been performed on the eyes of pigs, dogs, rabbits, cats, monkeys, and human beings. Clark and Ridley made measurements on living animals under anesthesia and again on the same eyes after the animal had been killed by exsanguination. As noted before, there is no significant difference in the results under these two conditions, except that, of course, during the period of exsanguination fluid enters the eye to replace the volume of blood lost from it.

The results of all these authors, when plotted with the pressure as abscissa and the volume as ordinate, all yield curves of the same type; concave upwards, rising more and more steeply as the higher levels of pressure are attained (fig. 2). At low pressures, considerable volumes of fluid can be introduced into the eye with only a small change in the pressure resulting, while at high pressure the same increase in volume is brought about only by a very considerable increase in pressure. Or to state the matter in another way, at low pressures all eyes are very distensible, but they become less and less distensible the more they are stretched. Clark has attempted to express these relations in terms of coefficient of elasticity and has shown that such a coefficient changes continuously with the pressure. Ridley has subjected eyes to a high pressure for some time, and has shown that after such

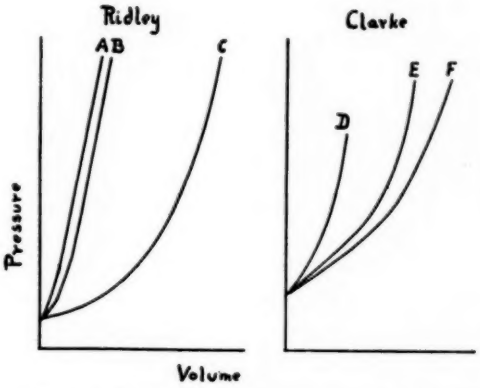

Fig. 2 (Friedenwald). Experimental data on the distensibility of the eyeball by Ridley and Clark. The scales of the two sets of data are not commensurate. A, normal human eye after prolonged exposure to high pressure; B, glaucoma; C, normal human eye; D, macaque; E, cat; F, dog.

stretching, the elasticity of the globe does not immediately return when the pressure is again reduced. The pressure-volume curve determined immediately after such stretching is much steeper throughout its whole course than it was before the eye was stretched. A similarly steep curve was obtained by Ridley on a glaucomatous eye.

Since, as Clark has shown, the coefficient of elasticity expressed in the form $V\frac{dP}{dV}$ varies continuously with the pressure, such a coefficient cannot readily be used to compare the elasticities of different eyes. A more rigid eye may, in fact,

be more distensible at low pressures than a less rigid one at high pressures. We have, therefore, reanalyzed the results of these authors in an attempt to find some simple mathematical relation in the data given which could be used as a measure of the rigidity of the eyeball independent of the varying pressures to which the eye was subjected during the determinations. Such a relation is, in fact, not hard to find. It is found that in each eye measured the proportional change in pressure produced by the same change in volume is constant irrespective of the pressure level at which the measurement is made, the value of this constant being greater in rigid eyes than in flaccid eyes at all pressures. This simple relation between pressure and volume changes can be demonstrated as follows: If we plot the data given by the authors referred to above, charting not the pressure itself, but the logarithm of the pressure as abscissae and the volume as ordinates, we find that, in each case, the data fall upon a straight line, the slope of the line being steeper the less distensible the eye.

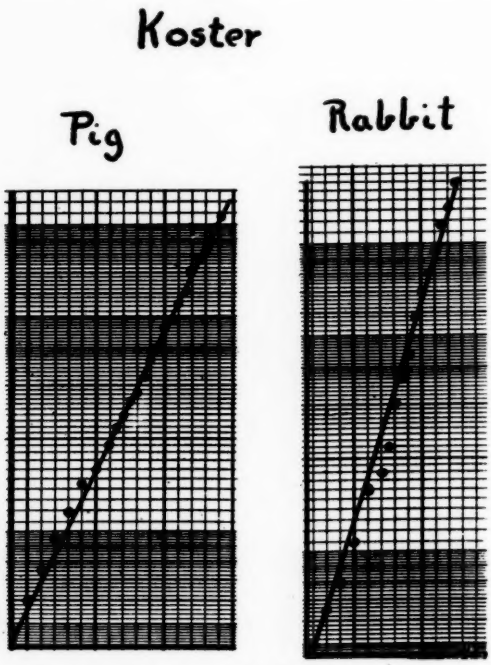

Fig. 3 (Friedenwald). Log pressure versus volume. Data of Koster.

In figures 3 to 5 we present the data of Koster, Ridley, and Clark charted in this

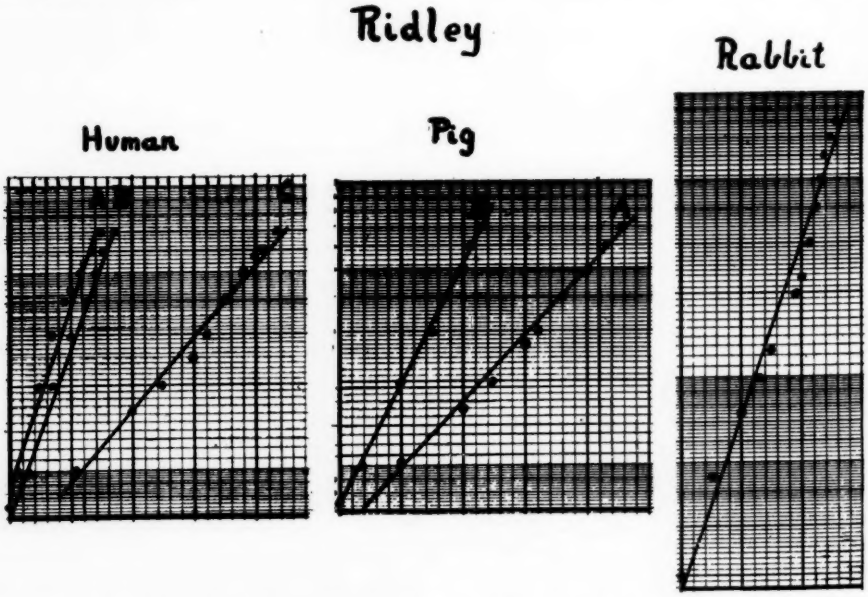

Fig. 4 (Friedenwald). Experimental data on distensibility of eyeball by Ridley. Log pressure versus volume.

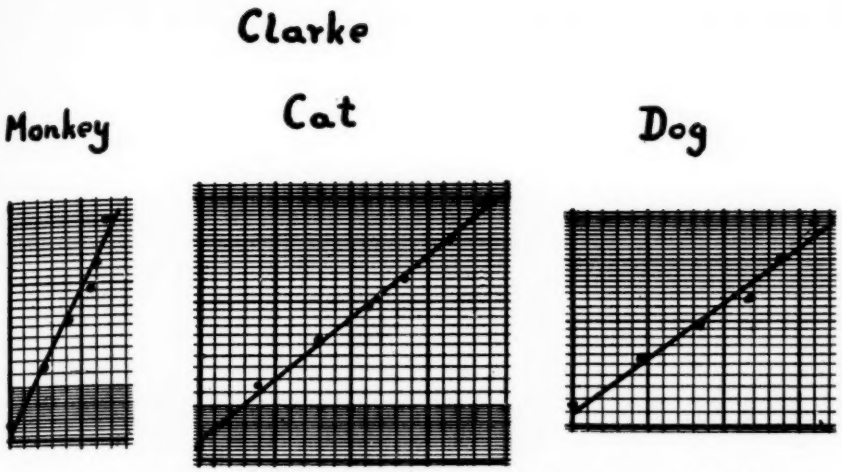

Fig. 5 (Friedenwald). Log pressure versus volume. Data of Clark.

way. Schultén's data (fig. 6) conform equally well to the same analysis, although Schultén's technique was severely criticized by Koster, who maintained that Schultén used too fine a cannula and did not take adequate precautions against leakage from the eye. The data of Schiötz do not conform quite so well to this analysis as do those of the others. Schiötz, however, reports only a single set of determinations on a single eye. Apparently, no precautions against leakage were taken and the pressure was measured with a tonometer. Both of these factors may be expected to introduce errors in the same sense as the deviations which his results show from those of the four other investigators.

The mathematical equivalent of this graphical analysis is as follows: It is assumed that for an eye of a given size the proportional change in pressure varies with the volume. Thus:

$$V\frac{dP}{P}=kdV \qquad \text{or} \qquad \frac{dP}{P}=\frac{k}{V}dV$$

Since the total change in volume is a small fraction of the volume of the eyeball, we may assume V to be roughly constant and equal to V_0, the volume of the eye before distention. Thus we may replace $\frac{k}{V}$ by a new constant K

$$\frac{dP}{P}=KdV.$$

Integrating we obtain:

$$\text{Log } P=c+KV.$$

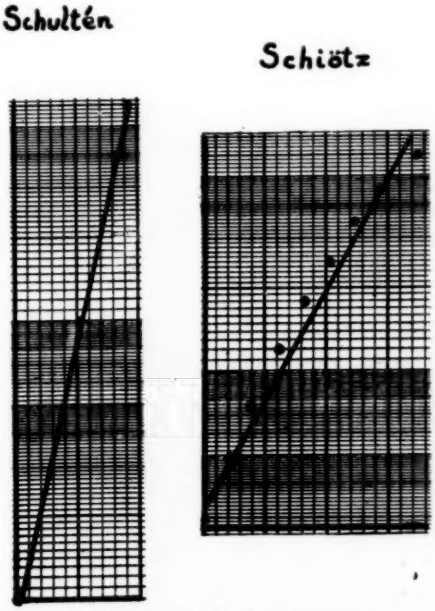

Fig. 6 (Friedenwald). Log pressure versus volume. Data of Schultén and Schiötz.

Finally we may replace KV by $K(V_0 + v)$, where V_0 is the original volume of the eye and v the volume of the distending fluid:

$$\text{Log } P = c + KV_0 + Kv.$$

And, since KV_0 is a constant we may combine this with c in a new constant C and obtain:

$$\text{Log } P = C + Kv.$$

In order to subject the results of this analysis to a more rigid test, we have fitted each set of determinations of Koster, Ridley, and Clark to the equation

$$\text{Log } P = C + Kv \qquad (2)$$

by the method of least squares. It is found that the results fit this formula extremely well, if those at pressures below 5 mm. Hg are omitted. This is not unexpected, for the formula, when applied to very low pressures, yields the absurd result that an infinite volume of fluid must be withdrawn from the eye to lower the intraocular pressure from a finite level to zero. This absurdity indicates that the formula just written does not express the law of the distensibility of the eye at extremely low pressures. Nevertheless, within the pressure range that is of clinical interest the fit is sufficiently good for practical purposes.

In figure 7 we have charted the deviations (log P observed minus log P calculated) for all the data given by these three authors, plotted in each case against the whole range of pressure observations above 5 mm. Hg. The heavy line indicates the mean deviation for different zones in the chart. The dashed lines give the range of probable error of the mean. It will be seen that at only one point on the curve does the line of zero deviation, that is, the perfect fit to our approximation formula, lie outside the zone of probable error of the mean of the actual deviations found. It may be concluded, therefore, that the approximation formula indicated above fits the observed data with quite satisfactory accuracy.

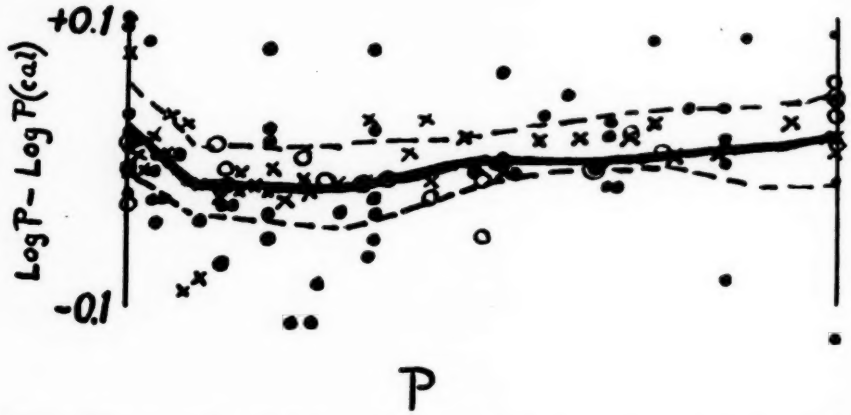

Fig. 7 (Friedenwald). Deviations of all published observations of Koster, Ridley, and Clark from values calculated by the formula: Log P = A + BV.

As we have said, the slope of the curve when the data are plotted according to the logarithmic formula is steeper the less distensible the eye. The slope of the curve is measured by the value of K in the formula. The value of K may, therefore, be taken as a measure of the resistance

which the eye exerts to distending forces. In order not to confuse this measure with the true coefficient of elasticity (which varies in each eye with the pressure) we shall call this new measure the coefficient of rigidity.

In table 1, the data of Ridley, Clark, and Koster are summarized. It will be seen that the coefficients of rigidity calculated for their results are all of the same order of magnitude. It should be noted that Clark and Ridley, knowing that the elasticity of the eye changes when high pressures are maintained for considerable periods, avoided this complication deliberately. Koster, who was chiefly concerned with errors introduced by leakage, tested his results over and over again after the eyes had been subjected to very high pressures. The results which Koster presents are the averages of many such determinations, and it would seem appropriate, therefore, to include Koster's results with those of Ridley on stretched eyes.

TABLE 1

VARIATION IN COEFFICIENT OF RIGIDITY

Author	Animal	Range of Pressure in mm. Hg		$K \times 10^3$
Clark	Dog	11.5	38.5	1.50
Clark	Cat	7.7	38.5	1.71
Ridley	Pig	7.5	70.0	2.31
Ridley	Human	7.5	70.0	2.35
Clark	Macaque	7.7	31.0	4.12
Ridley	Pig (stretched)	7.5	70.0	4.33
Ridley	Human (stretched)	7.5	70.0	5.90
Ridley	Rabbit	2.0	80.0	6.03
Ridley	Human (glaucoma)	7.5	70.0	7.14
Koster	Pig	6.0	107.0	8.78
Koster	Rabbit	6.5	158.0	15.33

Considering now the formula

$$\text{Log } P = C + Kv$$

we note that when $v = 0$, that is, when the injection of fluid is begun, $\log P = C$. C is, therefore, equal to the logarithm of the initial pressure in the eye, and we may write the formula in the form:

$$\text{Log } P = \text{Log } P_0 + Kv$$

or

$$\text{Log } \frac{P}{P_0} = Kv. \qquad (2a)$$

So far, we have concerned ourselves with the elasticity of the eye, as expressed by the resistance which the ocular tissues exert to a general increase in intraocular volume. We have now to consider what modifications must be introduced into our formula when the coefficient of rigidity is to be derived from experiments in which the total volume of the eyeball is unaltered but the shape distorted by the indentation produced by a tonometer. It may be argued that the expression of the coefficient of rigidity in terms of the change of volume is, after all, a mathematical tour de force that has little relation to the rational basis of the whole matter. The eye resists an increase in its volume because the ocular coats resist stretching; and the rational expression of the rigidity function must lie ultimately in either the change in area of the scleral coat or perhaps in the length of individual fibers in the sclera. The expression of the rigidity coefficient thus, merely in terms of change in volume, is possible because, in an object that approaches spherical form, the relation between changes in surface area, or between

changes in the length of linear elements in the surface, and changes in volume, is governed by simple laws. When the shape of the eyeball is distorted, the relations of surface and length to the volume of indentation are no longer so elementary, and the simple formula which we have developed above might no longer be applicable.

This argument may best be met by following it out in more rigorous detail. In the formula that we have outlined above:

$$\text{Log}\,\frac{P}{P_0}=Kv$$

it must be remembered that v refers not to the total volume of the eyeball, but merely to the relatively small change in that volume associated with the measured change in pressure. It would be more accurate to write the formula in the form:

$$\text{Log}\,\frac{P}{P_0}=K\Delta v \qquad (2b)$$

indicating by the letter Δ that we are concerned with relatively small finite changes in volume.

Let us suppose, now, that the actual determining factor is not volume but surface area. The volume of a sphere is given by the formula $V=\frac{4}{3}\pi R^3$; the surface of a sphere by $S=4\pi R^2$. Combining these two formulas, we have:

$$S=4\pi\left[\frac{3V}{4\pi}\right]^{2/3}.$$

Taking the derivative we have:

$$dS=CV^{-1/3}dV. \qquad (3)$$

This formula will hold to a first approximation also for the small finite changes in volume and surface with which we are concerned. We may, therefore, write:

$$\Delta S=CV^{-1/3}\Delta V \qquad (3a)$$

and since the changes in volume are relatively small, V may be regarded as a constant and we have

$$\Delta S=C_1\Delta V. \qquad (3b)$$

Similarly, if the length of a linear element in the sclera is to be regarded as the fundamental factor in rigidity, we can derive an equally valid approximation formula:

$$\Delta L=C_2\Delta V. \qquad (3c)$$

Our formula for the rigidity coefficient thus becomes:

$$\text{Log}\,\frac{P}{P_0}=K\Delta v=\frac{K}{C_1}\Delta S=\frac{K}{C_2}\Delta L$$

and it will be seen that the formula maintains its same simple forms no matter whether volume, surface, or length is thought of as the determining factor. Only the magnitude of the rigidity coefficient K or $\frac{K}{C_1}$ or $\frac{K}{C_2}$ will be different depending on which formula we choose, but, since C_1 and C_2 are constant for eyes of equal size, the three coefficients will be found to vary proportionately when the rigidity varies.

Returning now to the case in which the shape of the eye is deformed by the tonometer and ΔV refers not to change in total volume, for this is assumed to remain constant, but to the volume displaced by the tonometer, we see that, so long as the successive changes brought about by successively different degrees of indentation conform to some general self-consistent pattern, so long will the surface and linear elements be expressible in terms of V^n, or at most in terms of a finite series of such terms, the exponent n being a fraction less than unity. And again, the derivative of such an equation will be expressible when we consider V to be constant

as: $$dS = C_1^1 dV$$

or: $$dL = C_2^1 dV.$$

If, now, the change in the surface area of the ocular tunic is the fundamental factor in determining the rigidity of the eyeball, the logarithmic equation in the form:

$$\text{Log}\,\frac{P}{P_0} = \frac{K}{C_1}\,\Delta S$$

may be considered as having quite general validity irrespective of whether the surface area is changed by a total change in volume or by indentation. We may then combine this equation with that connecting surface area with the volume of the indentation, thus

$$\Delta S = C_1^1 \Delta V$$

and obtain

$$\text{Log}\,\frac{P}{P_0} = K\frac{C_1^1}{C_1}\,\Delta V$$

or, more simply, referring ΔV to the actual volume of the indentation instead of the fraction which that volume is in relation to the total volume of the eyeball:

$$\text{Log}\,\frac{P}{P_0} = K\,\frac{C_1^{1v}}{C_1}$$

We have thus returned to a formula of the same general form as that with which we started, only the numerical value of the new coefficient will be different from that of the old one. In general, it may be expected to be larger, since the ratio of the change in surface to change in volume diminishes with the closer approximation to spherical form. It will be seen below that the average normal value of the rigidity coefficient determined in this way is about 10 times as large as that found by Ridley in simply distending the eyeball.

A strictly similar argument may be used if, in actual fact, the change in length of the scleral fibers is the fundamental factor concerned. It will be seen, therefore, that the equation which we have developed may be applied to tonometric measurements, and that the objection outlined above is not valid. It follows, from the simple form of this equation, that, if we could determine the actual intraocular pressure and the volume of the indentation, when the tonometer rests on the cornea, then two successive measurements with different tonometer weights should suffice to establish, within the experimental error, a measure of the rigidity of the ocular coats.

C. First approximation

It will be seen from the foregoing discussion that our problem resolves itself first into an investigation of the area and volume of the tonometer indentation, for from the area we can by formula (1)

$$W = AP$$

calculate the actual pressure in the eye with the tonometer resting upon it, and from two pairs of determination of pressure and volume we can establish the coefficient of rigidity of the eyes.

What we can actually measure with the tonometer, however, is neither the area nor the volume of the indentation, only its depth. There are two ways of establishing the relation between depth, area, and volume of the indentation. The first consists in making some simplifying assumption from which approximation formulas may be derived, and fitting these approximation formulas to the data of the Schiötz nomogram. The second, more rigorous, consists in a direct computation of the values of these relations from experimental measurements. Since experimental data are available for this second method, the first might be omitted altogether, but it seems desirable to present the first approximation, at least in outline; for, by a comparison of these results

with those of a more rigorous and direct test, we shall be better able to understand what actually happens when the tonometer rests on the eye.

The simplest relation that we can suppose to exist between the depth and area of the indentation is that the radius of the indented area is a linear function of the depth:

$$R = a + bD$$

in which R is the radius, D the depth of the indentation, and a and b constants whose values are as yet unknown. This approximation formula is equivalent to the assumption that the slope of the indentation is constant, irrespective of the depth.

Under this assumption the area is expressed by the formula

$$A = \pi(a + bD)^2. \qquad (4)$$

Combining this with formula (1) we get

$$W = \pi(a + bD)^2 P$$

or

$$P = \frac{W}{\pi(a + bD)^2}. \qquad (5)$$

The value of a may now very readily be obtained from the Schiötz nomogram, since, when D is zero

$$P = \frac{W}{\pi a^2}.$$

The Schiötz nomogram gives four pairs of values of W and P for zero indentation of the cornea; namely, the points where the four curves of the chart reach the line for zero scale reading. Applying this formula to the Schiötz 1924 scale, which is, no doubt, much more reliable than his earlier scale, we find:

$$a = 1.62 \pm .02 \text{ mm.}$$

The close agreement of the four different values is most striking. That the radius of the least indentation which the plunger can produce is slightly greater than the radius of the plunger is not surprising, for it is the area of the indentation on the internal surface of the cornea that concerns us, and we would expect this to be slightly larger than the area of contact with the plunger.

The value of b cannot be estimated so readily. It cannot, however, be very far from unity, for the cornea, though pliable, is under some elastic tension when it is indented by the tonometer plunger and the slope of the indentation must, therefore, make an angle of approximately 45 degrees with the axis of the plunger. If the cornea is completely pliable, that is, shows no resistance to bending, and yet completely incapable of being stretched in the plane of its fibers, the value of $b = 1$ would be most closely approximated. The greater the resistance the cornea shows to bending, the larger will be the value of b. On the other hand, if the cornea showed no elastic limit, b would be smaller than unity, as it is when a soap bubble is indented. Experience shows that the cornea has little resistance to bending, but great resistance to stretching. The value of $b = 1$ may therefore be taken as probably the lower limit of possible values for b, but still not far removed from the actual value. With this second assumption, our equation becomes:

$$P = \frac{W}{\pi(1.62 + 0.05d)^2}$$

where d is the tonometer-scale reading. It must be remembered that P here is expressed in grams per square millimeter.

The assumptions that we have made so far are equivalent to the assumption that the indentation approximates a truncated cone in shape. The altitude of the cone is D, its base, and apex are circles whose radii are respectively $1.62 + D$, and 1.62 mm. The volume of such a cone may easily be computed according to the formula:

$$V=\frac{\pi}{3}\left[(1.62+D)^3-1.62^3\right]. \quad (6)$$

In this formula the volume of the indentation is seen to depend only on its depth and to be independent of the weight which has produced it. This is in accord with the conclusion of Schiötz who found that the indentations of the same depth were identical in shape, irrespective of the weight and pressure associated with them.

As a first test of these approximation formulas, we shall show how they may be fitted, with the aid of our logarithmic formula, to the date of the Schiötz nomogram. The Schiötz nomogram has, in fact, been the subject of some criticism. Both Wessely[13] and Seidel[14] found that the pressure readings indicated on the scale are slightly too low. Nevertheless, the scale is a self-consistent one. If, on the scale, we find that at a certain pressure the reading with the 5.5 weight is 3, that for the 7.5 weight 6, for the 10 weight 10, and for the 15 weight 14, then in view of the self-consistency of the data on which Schiötz built his scale, and in view of the wide clinical test to which the instrument has been put, it is safe to assume that there are eyes whose elasticity is such that if a reading of 3 is obtained with the 5.5 weight, the readings with the other weights will be very close to those indicated on the scale.

Our test, then, is as follows: We construct a chart (fig. 8) in which the abscissae represent volume of the indentation and the ordinates represent the logarithm of the intraocular pressure. Along the volume axis, we mark points corresponding to different scale readings in accordance with equation (6). On the ordinates erected on each of these points

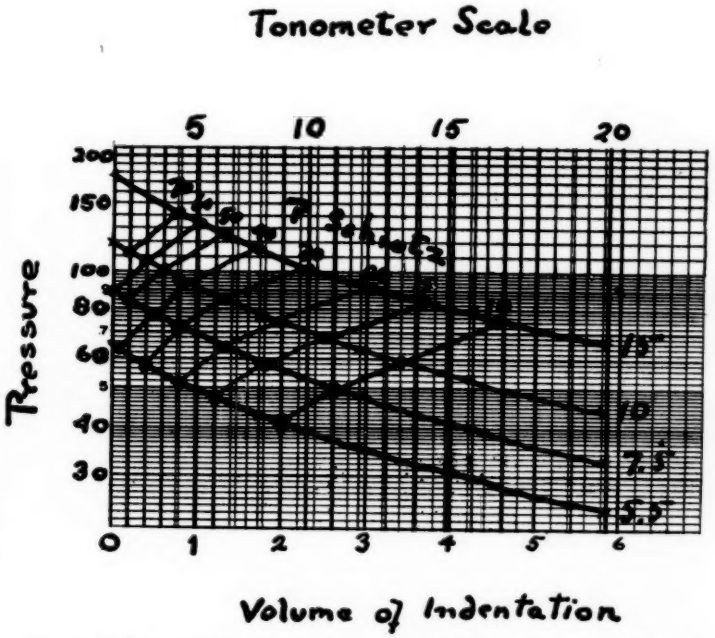

Fig. 8 (Friedenwald). Data of standard Schiötz scale charted in the form of Log P versus V with the aid of first-approximation formulas.

we mark the pressures corresponding to the four weights in accordance with equation (5a). The points for each of these weights are then connected in a continuous curve. Any point on the lowest curve represents by its abscissa the volume of the indentation and by its ordinate the logarithm of the intraocular pressure corresponding to a given scale reading with the 5.5 weight. If we make readings on an eye with all four different weights, each reading will be represented by a point on the chart, and if both the logarithmic law and the approximation formulas are cor-

rect, these points should lie on a straight line. Instead of taking such readings on a single eye, we have, in this first test, taken sets of readings from the Schiötz nomogram, using the four scale readings which the chart indicates should be given with the four different weights on an eye of a particular pressure. It will be seen that the lines connecting these sets of four points are nearly straight, in spite of the fact that our analysis has been based on a very crude approximation and in spite of the fact that, as we shall see, the Schiötz scale itself requires some corrections. In fact, the deviation of the points on this chart from straight lines is, when measured in terms of standard deviation, no greater than the deviation of Schiötz's curves from his own experimental data.

D. Second approximation

1. *Relation of tonometer readings to pressure.* The foregoing analysis points the way for a more rigorous analysis of the problem. We must obtain, by experimental measurement, a more accurate knowledge of the relation of depth to area and of depth to volume in the indentation produced by the tonometer. Fortunately, the data for such analysis are available in the experiments reported by Schiötz in the development of his tonometric nomogram. These experiments were reported in 1905,[15] 1909,[16] 1920[17] and 1925.[18]

Schiötz's experimental technique was as follows: He connected an eye with a water manometer and, with a tonometer resting on the cornea, measured the tonometer-scale readings corresponding to different intraocular pressures. In each case two sets of readings were taken. In the first, which he designated as the "open manometer" experiment, the connection between the eye and the manometer was open throughout the measurement. The pressure measured was, thus, the actual intraocular pressure with the tonometer in place. In the second, which he designated as the "closed manometer" experiment, the intraocular pressure was first brought to a particular level, and the connection with the manometer was then closed. The tonometer was then placed upon the cornea and a reading made. This second experiment approximates most closely the clinical procedure in tonometry, and it was the result of this second experiment that Schiötz used to establish his nomogram. However, the experimental error in the second procedure was greater than in the first, and the results of the first were, therefore, used to correct those of the second.

In the experiments of 1905, Schiötz used six eyes; in 1909, 10 eyes; in 1920, again 10; and in 1925, 30 eyes. The same tonometer was used in each series, but the technique of the experiments was varied slightly in the four series. In the first and second series, the eyes were freshly enucleated human eyes and were attached to the manometer by a cannula through the optic nerve. This procedure is unobjectionable, so far as the open-manometer measurements are concerned, but introduces important errors in the closed-manometer experiments. Since the weight of the eye was supported only by the cannula, the application of the tonometer must have caused not only the measured indentation of the cornea, but also an indentation of unknown amount in the posterior pole. For a given intraocular pressure, the tonometric reading would, therefore, be less in the experiment than in reading on a living eye. The Schiötz nomograms of 1905 and 1909, based on these readings, give pressures which have been recognized as too low.

Schiötz recognized this error and in his third and fourth series of experiments used the eyes of cadavers without enucleation, introducing a very fine cannula

through the sclera into the anterior chamber. The results of the closed-manometer experiments on these eyes furnished the basis of his final tonometric scale. For closed-manometer readings, we shall, therefore, use the data of the final series.

In regard to the open-manometer experiment, the situation is not quite the same. In the experiments of 1905, Schiötz was much concerned with the drying of the cornea, which, he found, caused considerable errors in his readings. He therefore wrapped the eye in a thin sheet of rubber tissue. It is obvious that such a procedure would radically alter the shape of the indentation. In the second and later series, this error was avoided by the frequent dropping of salt solution upon the cornea and the tonometer was applied directly to the cornea. Schiötz found certain systematic differences between the open-manometer measurements of the second and later series and considered the former as the more accurate. He attributes the difference to the small bore of the cannula used in the later series, which may have made the end point of equilibrium between tonometer and manometer readings less exact. In addition, some distortion of the cornea by a cannula placed through the limbus can hardly be avoided. Finally, drying of the cornea cannot be avoided as successfully in cadavers on which the measurements were made two to 20 hours after death as in freshly enucleated eyes. For these reasons, we shall follow Schiötz in using the data of the second series as most reliable in the open-manometer experiment. Since the open-manometer experiment gives the actual intraocular pressure with the tonometer in place, we shall be concerned, in the first instance, with these results.

Schiötz charted the results of his experiments, manometer readings versus tonometer readings, and found that for each tonometer weight the readings formed a curve resembling a hyperbole, and on the advice of his brother, who was a professor of physics, fitted his experimental data to a formula which, in our notation would be:

$$P=\frac{W}{a+bD}. \tag{7}$$

The similarity and differences between this and our approximation formula:

$$P=\frac{W}{\pi(a+bD)^2} \tag{5}$$

are of interest. In applying this formula, Schiötz found that, while the value of b remained fairly constant throughout his experiments, a different value of a was required to fit the data obtained with each tonometer weight. The value of a could, however, be expressed as a function of W:

$$a=u+vW. \tag{8}$$

The procedure of Schiötz consists, therefore, in the use of three arbitrary constants.

In order to find out whether formula (5) or (7) fits the data more exactly, we have written these formulas in the form:

$$a+bD=\frac{W}{P} \tag{7a}$$

$$a+bD=\frac{1}{\sqrt{\pi}}\sqrt{\frac{W}{P}}. \tag{5a}$$

In figure 9, we have charted Schiötz's experimental data using $\frac{W}{P}$ for ordinate and D for abscissa. In figure 10, we have charted the same data, using $\sqrt{\frac{W}{P}}$ as ordinate and D as abscissa. If equation (7) correctly represents the relations, the points charted should fall on a straight line in figure 9 and on a curve in figure 10. If equation (5) is the correct one, the reverse should be true. The actual findings are somewhat surprising. For small

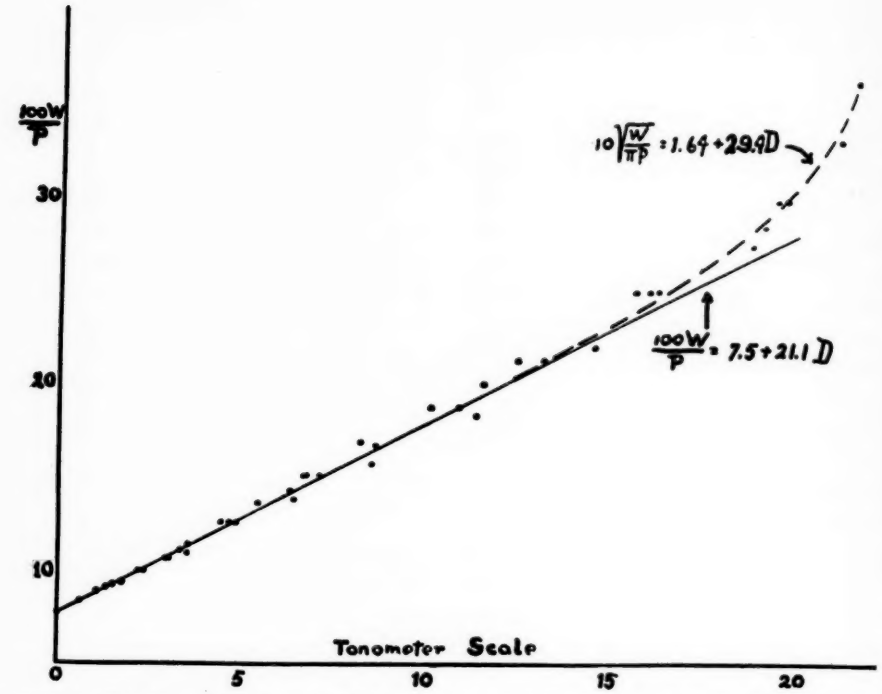

Fig. 9 (Friedenwald). Data of Schiötz's open-manometer experiments (1908) charted as a linear function of W/P.

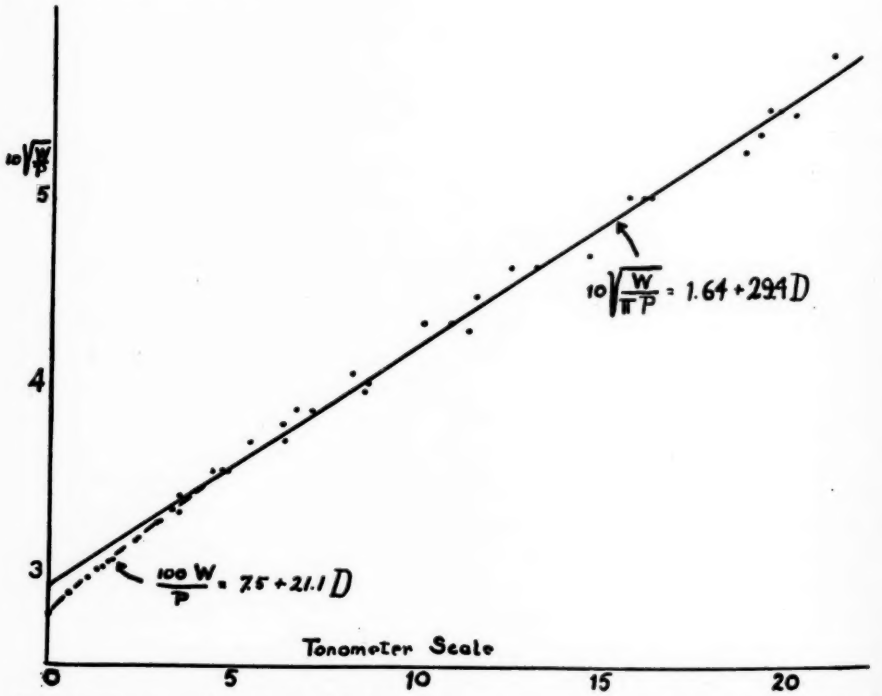

Fig. 10 (Friedenwald). Data of Schiötz's open-manometer experiments (1908) charted as a quadratic function of W/P.

tonometer-scale readings the Schiötz formula gives an excellent fit, while for scale readings over five, formula (5) gives a much closer approximation. By using the two formulas for the different parts of the scale, we do not require different values of our constants for each weight. The computed values of intraocular pressure for the four different weights at various tonometer-scale readings are shown in figure 11, and table 2.

TABLE 2

	Computed values for corneal indentation				Intraocular pressure with tonometer resting on eye			
Tonometer Scale Reading	Depth mm.	Area of Base mm.^{2}	Radius of Base mm.	Volume mm.^{3}	5.5 gm.	7.5 gm.	10 gm.	15 gm.
0	0.00	7.75	1.571	0.00	52.2	71.2	94.9	142.3
1	0.05	8.75	1.669	0.37	46.1	63.1	83.4	126.2
2	0.10	9.75	1.762	0.82	41.5	56.6	75.4	113.1
3	0.15	10.75	1.850	1.35	37.6	51.3	68.4	102.6
4	0.20	11.75	1.934	1.93	34.4	46.9	62.6	93.9
5	0.25	12.75	2.015	2.55	31.7	43.2	57.6	86.4
6	0.30	13.75	2.093	3.25	29.4	40.1	53.5	80.2
7	0.35	14.75	2.170	3.94	27.4	37.3	49.8	74.6
8	0.40	15.75	2.241	4.74	25.7	35.0	46.7	70.0
9	0.45	16.75	2.310	5.50	24.1	32.9	43.9	65.8
10	0.50	17.80	2.381	6.39	22.7	31.0	41.3	61.9
11	0.55	18.92	2.455	7.30	21.4	29.0	38.9	58.0
12	0.60	20.07	2.528	8.25	20.2	27.5	36.6	55.0
13	0.65	21.25	2.601	9.33	19.0	26.0	34.6	52.0
14	0.70	22.47	2.674	10.43	18.0	24.6	32.7	49.1
15	0.75	23.71	2.748	11.55	17.1	23.3	31.0	46.6
16	0.80	25.00	2.821	12.73	16.2	22.1	29.4	44.1
17	0.85	26.31	2.894	14.03	15.4	21.0	27.9	42.0
18	0.90	27.67	2.968	15.40	14.6	19.9	26.6	39.9
19	0.95	29.05	3.042	16.80	13.9	19.0	35.3	38.0
20	1.00	30.47	3.115	18.35	13.3	18.2	24.1	36.2

This conclusion can be tested further by statistical methods. We have applied the Schiötz formula to the data by the method of least squares and computed the standard deviation. Using different values of a and b for each weight, the standard deviation found is 0.67 units of the tonometer scale. If the average value of b is used throughout and the value of a computed according to formula (8), as Schiötz did in the final drawings of his curves, the standard deviation is 0.75 units of the Schiötz scale. If, on the other hand, we use the Schiötz formula for the smaller scale readings, and formula (5) for the larger scale readings the standard deviation is only 0.39 units. At first sight, this method would appear to consist in the use of four independent constants, but the condition that the two curves should be tangent to one another reduces the number to three. Applying this condition to the data, we find that the standard deviation is increased only to 0.40 units of the tonometer scale and is, therefore, close to the probable experimental error in reading the tonometer. It would seem, therefore, that this method of curve fitting is much more exact than that used by Schiötz.

The discovery that the Schiötz scale is inexact for large tonometer deflections is by no means new. Schiötz himself realized that his curves fitted the data well only within a certain range and advised that the intraocular tension should be determined only on the basis of deflections which fell between 3 and 10 on the tonometer scale. Indeed, the extraordinary

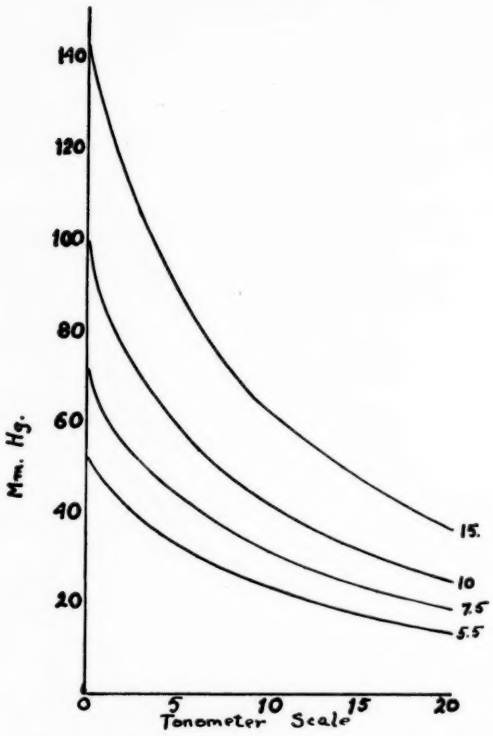

Fig. 11 (Friedenwald). Intraocular pressure with the tonometer resting on the cornea.

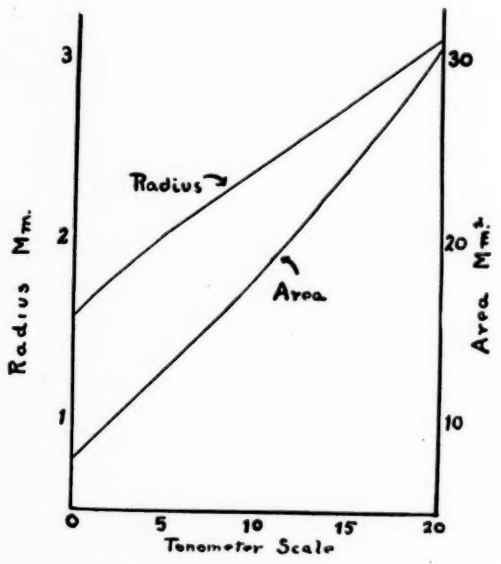

Fig. 12 (Friedenwald). Radius and area of indentation produced by tonometric plunger.

perspicacity with which Schiötz analyzed his own results has been a recurring source of help to us in our study. The limitation of the useful range of scale readings that Schiötz indicated is of no

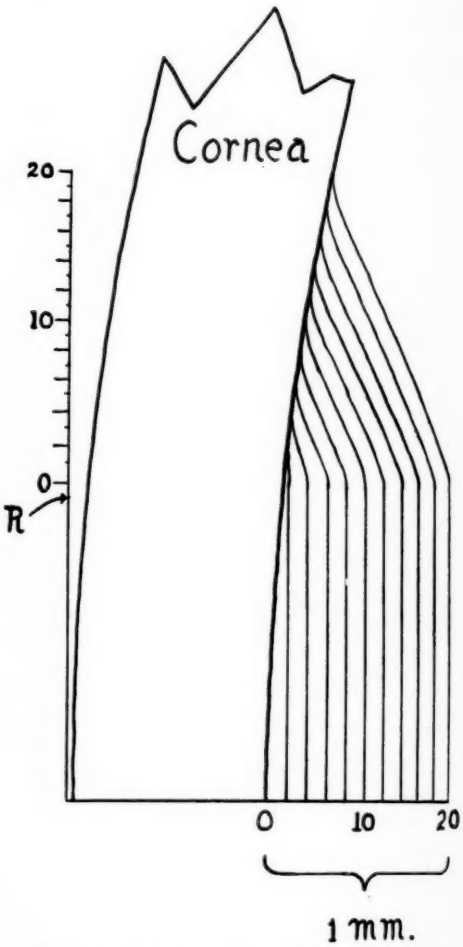

Fig. 13 (Friedenwald). Radius, depth, and approximate cross section of tonometer indentations drawn to scale. R, shows the radius of the tonometer plunger. The horizontal base line is the axis of the tonometer.

disadvantage in the ordinary method of using the tonometer. For our particular study, however, it is essential to be able to compare a small deflection obtained with one weight with a larger deflection obtained with another weight,

and it is for this reason that we have pursued this analysis in such tedious detail.

The formula W = AP is quite general and applies to the present analysis just as it did to the earlier approximations. The area and hence radius of corneal indentation for each weight and tonometer-scale reading may be calculated. It is found that the area and radius is the same for each tonometer-scale reading irrespective of the weight used (fig. 12, table 2). This conclusion had already been reached by Schiötz from the analysis of the same data. What explanation is there for the curious fact that with small degrees of indentation, the area of the indentation is a linear function of the depth while for deeper indentations not the area but, as one would expect *a priori*, the radius is a linear function of the depth? If we reconstruct graphically (fig. 13) the relations between depth and radius indicated by our study of Schiötz's experimental data, we find that the average slope of the walls of the indentation from crater to pit is constant when the depth of the indentation is over .025 mm. (5 on tonometer scale), but that for shallow indentations the slope of the declivity is less and less. For zero indentation, the cornea is, of course, convex. However, with the tonometer in place, even with zero reading, the convexity of the cornea is not so great as it is without the tonometer, for the foot plate of the Schiötz instrument has a radius of curvature of 15 mm. while the radius of curvature of the normal cornea varies from 7 to 8 mm. It is evident, therefore, that the zone of scale readings for which formula (5) is inapplicable must be related to the degree of curvature of the cornea at zero scale reading.

This conclusion is open to experimental test, for one can make measurements similar to those of Schiötz with the open manometer, using tonometers whose foot plates have different radii of curvature.

2. *Numerical value of the constants.* Before closing our discussion on this phase of the problem, some consideration of the numerical value of the constants is desirable. The solution, by the method of least squares of our analysis of Schiötz's experimental data, leads to the formulas:

$$P=\frac{W}{7.75+D} \quad \text{for } D<4.82 \qquad (7b)$$

$$P=\frac{W}{(2.92+0.13D)^2} \quad \text{for } D>4.82 \qquad (5b)$$

In these equations, the pressure, P, is given in grams per square millimeter, the depth of the indentation in tonometer scale readings. Since one unit on the tonometer scale represents 0.05-mm. indentation, we may write:

$$P=\frac{W}{7.75+20d} \qquad (7c)$$

$$P=\frac{W}{(2.92+2.60d)^2}=\frac{W}{\pi(1.64+1.46d)^2} \qquad (5c)$$

From formula (7c) we calculate the radius of the area of indentation for zero indentation to be 1.57 mm., which is again close to the magnitude of the radius of the tonometer plunger. The fact that the corresponding measure obtained from formula (5c) yields a slightly larger value (r = 1.64 mm.) indicates that the cornea does, in fact, exert some resistance to bending. Similarly the value of b found in (5c) (b = 1.46), being greater than unity, is also an indication of the small but nevertheless real resistance which the cornea offers. The average slope of the indentation is not 45 degrees as we assumed in our first approximation but roughly 35 degrees for an indentation deeper than .024 mm., the slope decreasing and finally becoming negative for very slight indentation.

An important conclusion to be drawn from this phase of our analysis is that any mechanical device that is used to standardize tonometers should have as its artificial cornea a membrane which possesses the same physical characteristics as the cornea; that is, it should be very pliable but should resist stretching. Cham-

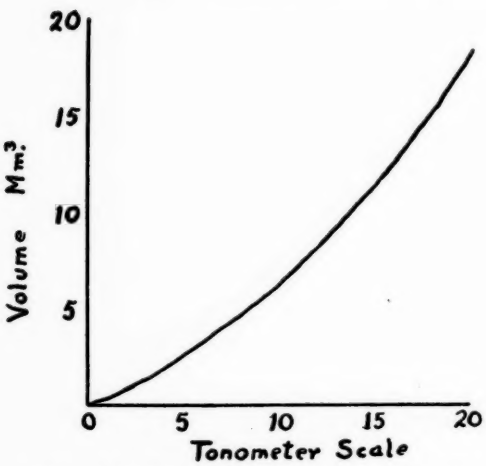

Fig. 14 (Friedenwald). Volume of indentation computed from the previous figure.

ois or kid skin would, for instance, be more suitable than rubber.

3. *Volume of the indentation.* There appears to be no satisfactory experimental method of determining the volume of the indentation. As will be seen from our first approximation, the maximum volume is of the order of 15 cu. mm., and in an enucleated eye the unavoidable leakage even at low pressures is of nearly the same order of magnitude during the period required for measurement. In the absence of any direct method, we must pursue the same general plan here as in the first approximation, though our more detailed knowledge of the area of the base of the indentation can afford some corrections to our earlier estimate. Since the form of the indentation is somewhat complex, we have attempted to estimate its volume by graphic methods.

In figure 13 we have drawn the surface of the cornea as having a radius of curvature of 15 mm., as it must to conform with the tonometer foot plate. The points connected by the dotted lines represent the successive positions for successive tonometer-scale readings of the margin of the indentation, and of a point immediately beneath the edge of the tonometer plunger. Naturally, it is with the posterior surface of the cornea that we are con-

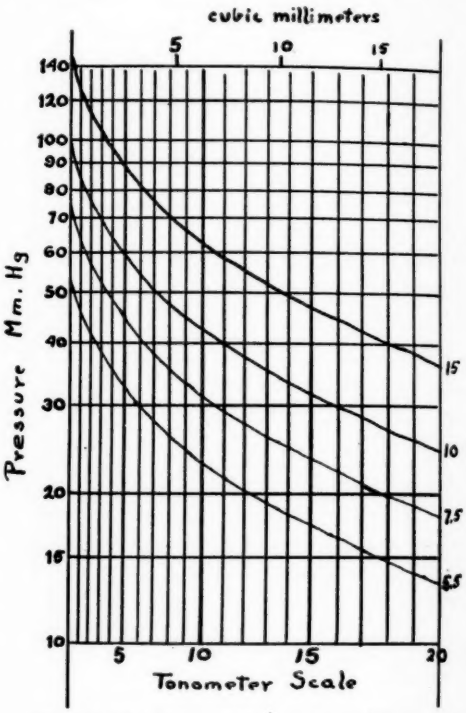

Fig. 15 (Friedenwald). Log-pressure-versus-volume chart for Schiötz tonometer.

cerned. Now, if the lamellae of the cornea are so bound to one another that successive layers cannot readily slip in relation to each other, we should conclude that, since the thickness of the cornea is roughly 1 mm., the curvature which the indentation makes facing the aqueous should not have a radius of curvature of less than one millimeter. We have attempted to connect the points on our figure which are now joined by dotted lines,

by curves whose maximum curvature posteriorly is of this order, and have found that some of the pairs of points cannot possibly be connected in this way, while for others an absurdly acute angle is produced under the edge of the indentation. We must conclude, therefore, that the lamellae of the cornea easily slip over one another and that the curvature posteriorly can have a radius of less than one millimeter.

The second attempt at the solution of this problem has consisted in supposing that the value of a in the equation

$$P = \frac{W}{\pi(a + bD)^2}$$

represents a flex in the curve connecting the crater with the pit of the depression. Since this equation is applicable for values of D over 5, we have assumed that at D = 5, the curve is S-shaped, with a flex at the point determined by a; while for values over 5 there is a straight line connecting oppositely curved elements at either end. For values of D less than 5, we have approximated the same curves as nearly as possible. This set of curves is shown in figure 13. We have then computed the volume of discs of the cross section shown

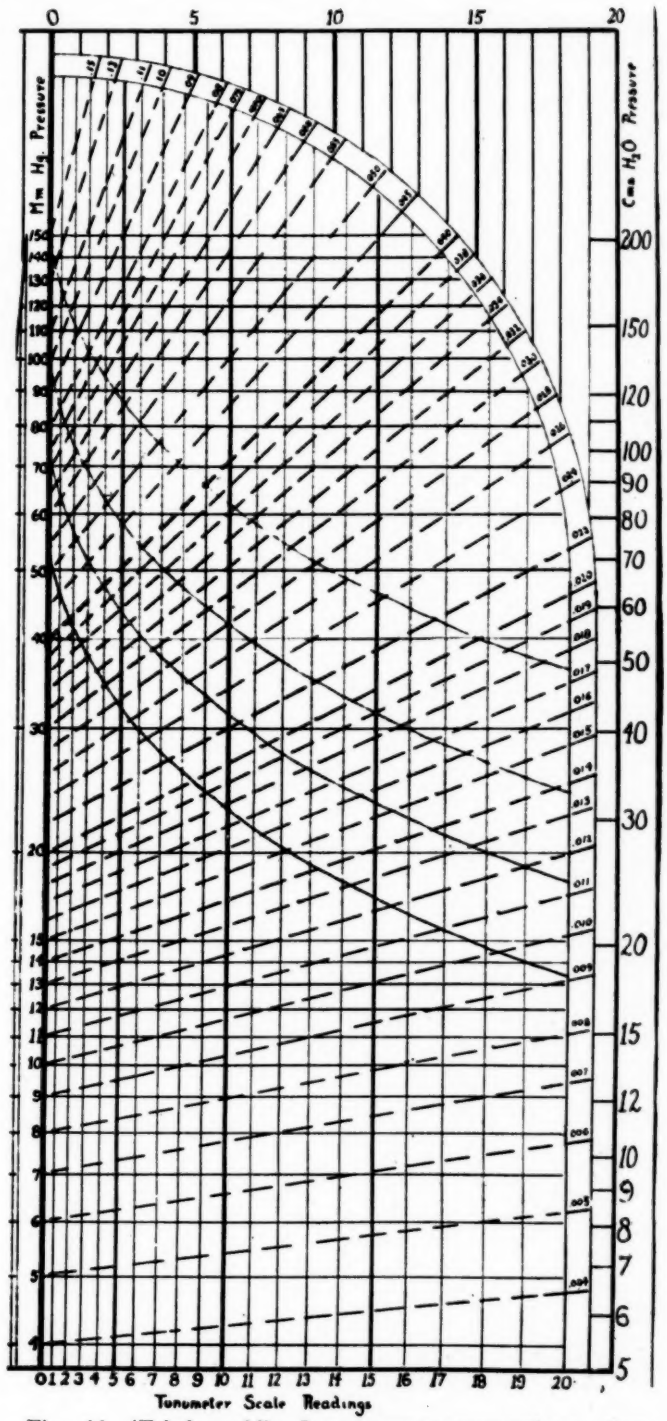

Fig. 16 (Friedenwald). Log-pressure-versus-volume chart with scale of rigidity.

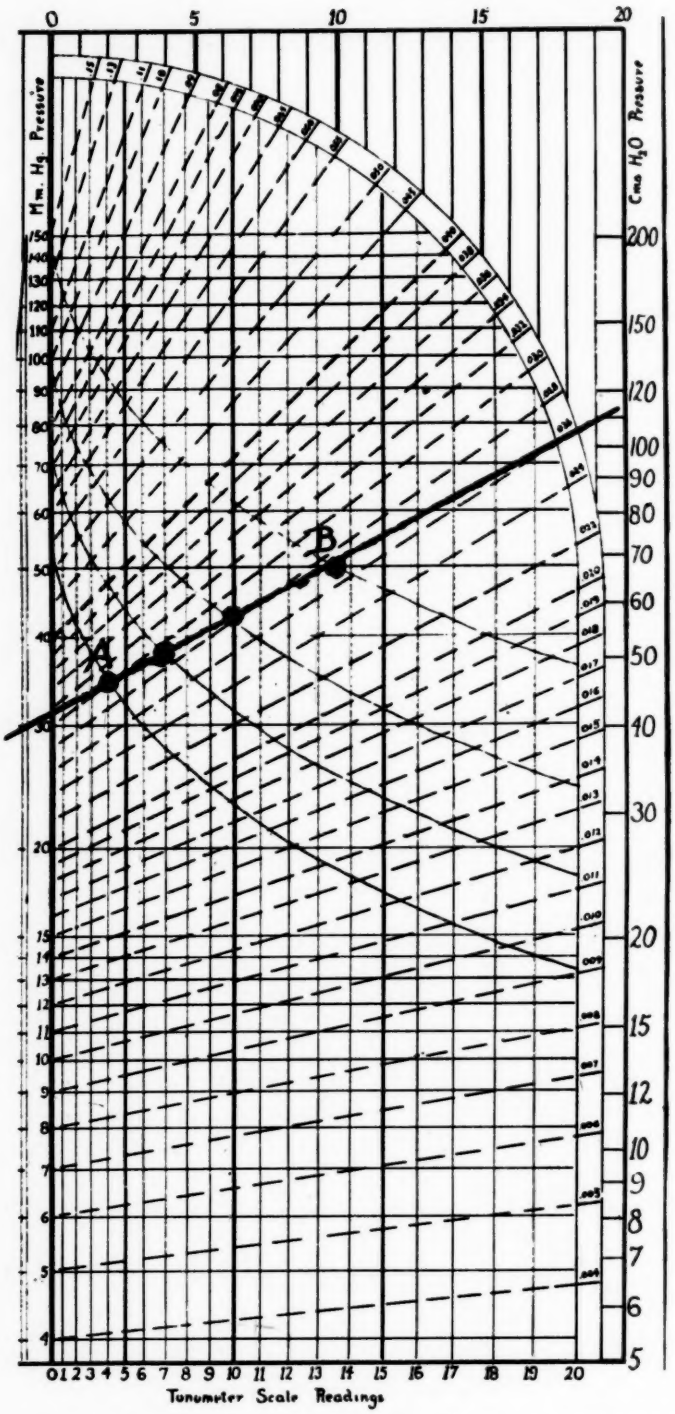

Fig. 17 (Friedenwald). A set of tonometric readings made with all four tonometric weights when plotted on the chart determines a line whose slope, in this case, 0.021, is the rigidity coefficient of the eye.

by simple graphic methods. The resulting function connecting volume with depth is shown in figure 14. It does not differ very markedly from the values calculated in our first approximation. A summary of the results of these calculations is given in table 2.

We must now test the validity of this graphic solution. To do so, we construct a chart (fig. 15) similar to that shown in figure 8, using our second approximation for the relations between D and P, and between D and V, and test this chart in the same way as we did that of figure 8. Instead of using as test data measurements derived from the Schiötz scale, we have used the actual data of Schiötz's "closed manometer" experiments which are the basis of his scale. In his 1924 paper, Schiötz reports on the tonometer-scale readings obtained on eyes in which the pressure, before applying the manometer, was adjusted to a certain level, and the connection with the manometer then closed. Measurements were made at a variety of initial pressures and with each of the four tonometer weights on 30 eyes. Charting the average of his results, we find

that the sets of points corresponding to each initial intraocular pressure fall very nearly in straight lines.

As a second test, we have applied the same method to similar sets of data obtained from clinical measurements. In these measurements tonometer readings with all four weights were made successively on the same eye, a short period being allowed to elapse between each measurement to enable the intraocular pressure to recover from the disturbance produced by the previous measurement. These data again are found to fall on approximately straight lines, although, of course, the deviations due to errors in measurement are greater in this clinical series than in the averaged results of Schiötz's tests on 30 eyes with the intraocular pressure controlled by a manometer.

It would appear, as a result of this analysis, that we have now succeeded in designing a chart on which successive tonometer readings with different weights on a given eye determine a line, that this line is the same no matter which pair of the weights is used, and that the slope of the line is greater the more rigid the eye. We shall use the slope of such lines as a measure of the rigidity of different eyes and shall symbolize the slope by the letter R. In order to avoid the tedious arithmetical calculation of the slope for each observation we have in figure 16 redrawn the chart of figure 15 with the addition of a set of lines of varying slope. Figure 17 shows a set of tonometric readings made with all four weights on a normal eye plotted in this chart. The slope of the line drawn through these four points is readily seen to be .021.

4. *The initial intraocular pressure.* We suppose that by successive readings with different tonometer weights we have determined two or more points on our chart, and have connected these points by a line (figure 17). This line, AB, represents the continuous relation between the intraocular pressure and the volume of indentation produced by the tonometer in distorting the shape of the cornea. If we could continue this line out to the left, we should reach a point where the volume displaced by the tonometer was zero. The ordinate of this point would then give us a measure of the intraocular pressure before the tonometer was placed on the eye. Our problem consists in finding the abscissa for zero volume displacement.

Obviously, this abscissa is not the same as that for which the tonometer scale reading is zero, for this presents not zero volume displacement, but the volume displacement in an eye on which a tonometer rests when the plunger of the tonometer is loaded with a weight just sufficient to give a zero scale reading. The pressure in the eye with zero scale reading is given by the ordinate of the point where the line AB crosses the line for zero scale reading.

Since, from formula (7) and Schiötz's data with the open manometer, we have computed the area of the cornea supporting the plunger at zero indentation to be 7.75 mm.^{2} we can find the weight of the plunger that would give a zero scale reading on an eye by the formula $W = 7.75\ P_t$, where P_t represents the pressure in the eye with the tonometer at zero scale reading. The weight of the tonometer aside from the plunger and lever arm is 12 grams. The total weight at the zero scale reading is, therefore, $12 + 7.75\ P_t$. Finally, the corneal area, supporting this weight is

$$\frac{12 + 7.75P_t}{P_t}.$$

This formula becomes inapplicable when the computed area of contact is greater than the area of the tonometer foot plate. For the Schiötz tonometer, the diameter of the foot plate is 9 mm. and the foot plate must be in contact with the

cornea over its whole area, if the intraocular pressure with the tonometer in place is 12 mm. Hg or less. It is doubtful whether there are many eyes in which the

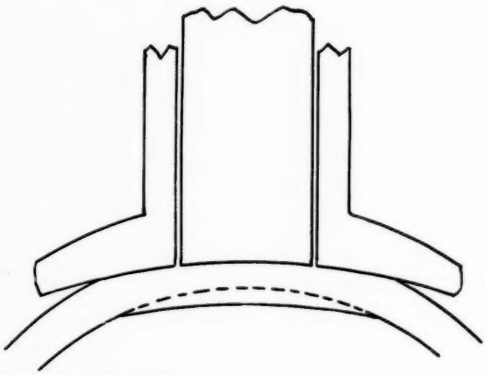

Fig. 18 (Friedenwald). Distortion of cornea by tonometer foot plate.

pressure is so low and the elasticity so great that a pressure of less than 12 mm. Hg is attained when the tonometer rests upon it. Furthermore, as noted above, the logarithmic relation between pressure and

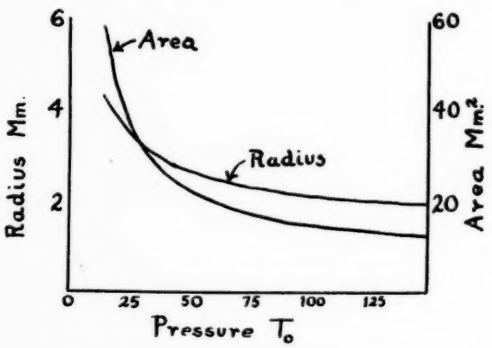

Fig. 19 (Friedenwald). Radius and area of contact between cornea and tonometer foot plate for zero reading on tonometer scale.

volume ceases to hold at pressures lower than 5 mm. Hg. It is plain, therefore, that for these very low pressures our measurements must be in error. But while the error may be relatively large for these small pressures, it must by the same criteria, be absolutely small. Finally, as will be shown below, there is reason to believe that the Schiötz nomogram gives consistently too low a reading of the pressure in the eye, so that the number of cases in which such very low pressures exist is probably much less than clinical experience with the aid of the Schiötz nomogram would lead us to believe.

The radius or curvature of the tonometer foot plate is given as 15 mm., while that of the average cornea is given as 7.8 mm. It is apparent that over the area of

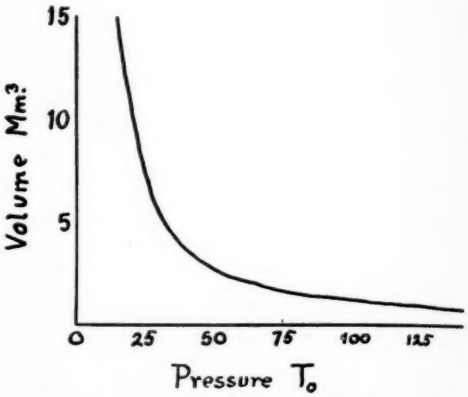

Fig. 20 (Friedenwald). Volume of corneal distortion produced by tonometer foot plate.

contact between tonometer and cornea, the cornea must be flattened (fig. 18). The volume displaced by this flattening may be calculated as the difference in volume between the segments of two spheres when the area of the base of the segments is that given above, while the radii of the spheres are 15 and 7.8 mm. respectively.* We have computed the vol-

* The volume of the meniscus displaced by the tonometer foot plate for a given area of contact is calculated as follows: The volume of a segment of a sphere is given by the formula $V = a^2(r - \frac{a}{3})$ in which a is the altitude of the segment, r the radius of the sphere. The altitude a is equal to $r(1 - \cos \alpha)$ where α is half the angle subtended by the base of the segment at the center of the sphere. Knowing the area of the base of the segment, that is, the area of contact between tonometer and cornea, the value of α can readily be calculated, and using

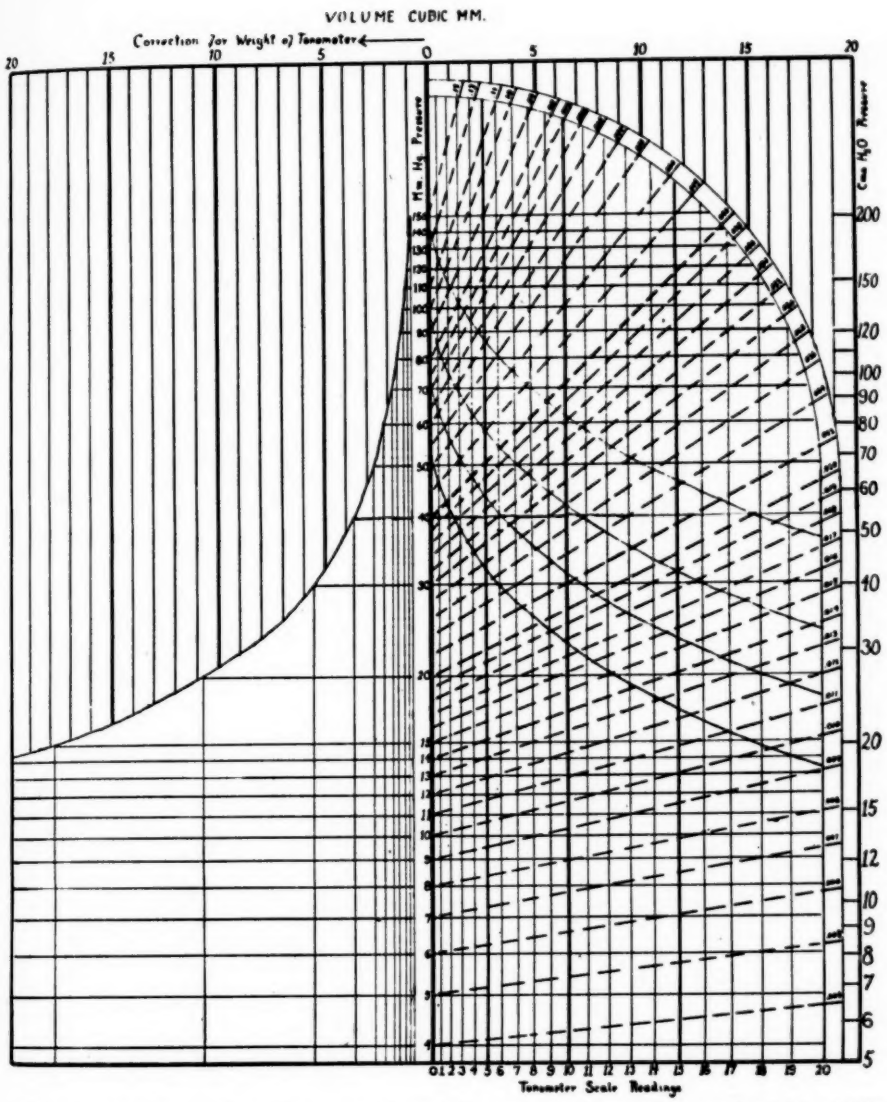

Fig. 21 (Friedenwald). Chart for determining intraocular pressure and ocular rigidity from tonometric readings.

ume for the various values of P_t and obtained in this way the abscissa for zero volume displacement for each value of P_t.

for r first the radius of curvature of the cornea and then the radius of curvature of the tonometer foot plate, one obtains the volumes of two spherical segments. The difference between these two volumes is the volume of the meniscus. A summary of these calculations is given in table 3 and figures 19 and 20.

If we extend our line AB until it reaches this abscissa to the left of the axis for zero tonometer-scale reading, we shall find the point on our chart whose ordinate is a measure of the intraocular pressure without the tonometer. We shall call this pressure P_0.

In figure 21 will be seen a chart similar to that of figure 16 in which we have

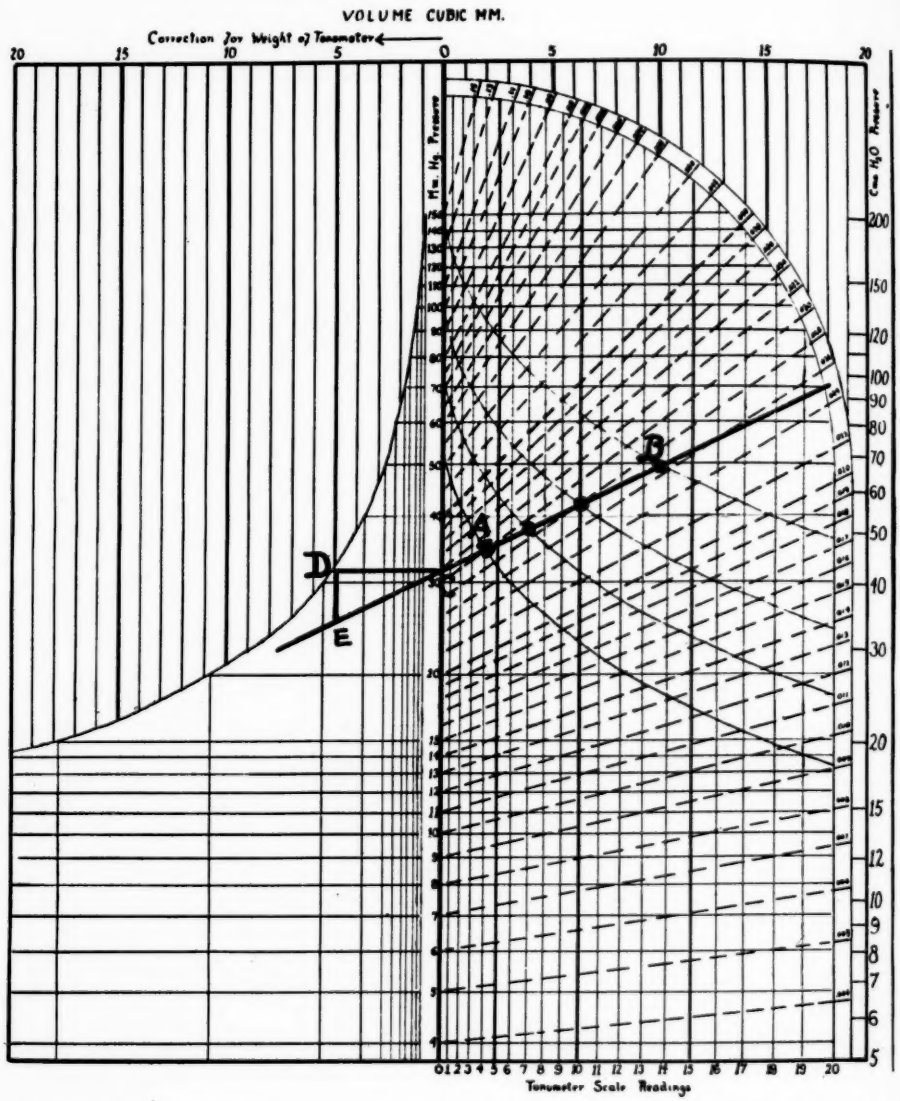

Fig. 22 (Friedenwald). Illustrating the use of the pressure-rigidity nomogram in determining the intraocular pressure and ocular rigidity from a set of tonometric readings with different weights. The intraocular pressure, indicated by E, in this case is 25 mm. Hg. The ocular rigidity, indicated by the slope of the line E-B, is 0.021.

added a curve based on these calculations. The curve to the left of the axis for zero tonometer-scale readings gives by its abscissa the volume displaced by the tonometer foot plate corresponding to each value of P_t. In using this chart to compute P_0, we first mark off two points, A and B (fig. 22), corresponding to the tonometer readings on an eye with two different weights. These two points are connected by a straight line which we extend to the left. The slope of this line is the coefficient of rigidity, R. From the point where the line AB crosses the axis for zero scale reading, we draw a line CD horizontally to the left until it meets

our new curve at D. From D we draw a line vertically downward until it meets the line AB at E. The ordinate of E on the logarithmic scale is the pressure P_0.

We can now compare the computed pressure, P_0, with that determined in Schiötz's experiments with the closed manometer. If we chart on our nomogram the data given by Schiötz as to the tonometer reading which he obtained with each of the four weights on an eye with a given initial pressure, we obtain data which fall very nicely on a straight line. Extending this line downward and to the left we find the corresponding value P_0. Consistently this value is slightly higher than that reported by Schiötz, the difference amounting to 1-3.5 mm. Hg. The discrepancy is greatest in the region between 20 and 40 mm. Hg intraocular pressure, falling off in the regions of high and low pressure.

Ordinarily, it would be the part of wisdom to enter this difference between the observed and calculated P_0 as a correction to our theory so as to make the theory conform to the experiment, but Wessely,[13] Seidel,[14] and McLean[19] have made measurements on living eyes which indicate that the Schiötz values for P_0 are too low. Unfortunately, the measurements of these authors were made with a single tonometer weight for each pressure, and we do not know, therefore, the coefficient of elasticity of the eyes which they studied. Assuming, however, that this coefficient is the same as the average one obtained from the Schiötz data, we can compare Wessely's, Seidel's, and McLean's measurements with those of Schiötz for the closed tonometer and with our own theoretical calculation. It is found that all these measurements on living eyes lie closer to our theoretical value of the correction factor than they do to the value determined experimentally by Schiötz. It seems likely, therefore, that some systematic error entered into Schiötz's results, leading him to estimate the pressure P_0 as from 1-3.5 mm. Hg too low, or his tonometer scale readings too high by correspondingly small values.

It is difficult to speculate on the possible sources of this error. It will be remembered that we have followed Schiötz's lead in assuming that his experiments with the closed manometer in the final series were more accurate than in

TABLE 3

VOLUME OF FLUID DISPLACED BY TONOMETER FOOT PLATE

P_t mm. Hg	P_t gm./mm.²	W_0 gm.	W_t gm.	A_t mm.²	R_t mm.	V_t mm.³
7.35	.10	.775	12.775	127.75	6.38	
14.7	.20	1.550	13.550	67.75	4.64	
22.05	.30	2.325	14.325	47.75	3.88	12.50
29.4	.40	3.100	15.100	37.75	3.46	8.20
36.75	.50	3.875	15.875	31.75	3.17	5.45
44.1	.60	4.650	16.650	27.75	2.96	4.15
51.45	.70	5.325	17.325	24.75	2.80	3.20
58.80	.80	6.200	18.200	22.75	2.69	2.55
66.15	.90	6.975	18.975	21.08	2.59	2.30
73.5	1.00	7.750	19.750	19.75	2.51	2.10
80.85	1.10	8.585	20.585	18.71	2.44	1.85
88.2	1.20	9.300	21.300	17.75	2.37	1.60
102.9	1.40	10.650	22.650	16.18	2.27	1.35
117.6	1.60	12.400	24.400	15.25	2.20	1.25
132.3	1.80	13.950	25.950	14.42	2.14	1.10
147.0	2.00	15.500	27.500	13.75	2.09	.95

any of his preceding series, and have used this for the analysis of the values of P_0. Our curves, however, are based on the Schiötz experiments of the second series with the open manometer, which he regarded as more accurate than the corresponding data of the latter series. Schiötz himself noted that between these two series of experiments with the open manometer there were some consistent differences. It is interesting to note that these differences are in precisely the same sense and of the same order of magnitude as those that we have found.

Since errors due to leakage cannot complicate the results of experiments with the open manometer, these seem a much more solid base upon which to build a tonometer scale. It is, however, only by taking into account the elasticity of the eyeball that these results can be applied. Schiötz, who left the elasticity out of his calculations, was forced to base his scale upon the closed-manometer experiments. It is most fortunate for us that he reported the open-manometer experiments in such detail, since he performed these only as an indirect control on his results with the closed manometer.

In view of this, we shall adhere to our theoretical calculation of the value of P_0, omitting the correction which would be required to make our calculated value conform more exactly to that of Schiötz. In general, therefore, the intraocular pressure as determined by our method will be slightly higher than that determined from the same tonometer readings with the Schiötz chart. The difference will be greater the more distensible the eye, but if the eye is very rigid, the intraocular pressure will be found by our method to be less than that found with the Schiötz chart. This difference is not arbitrary. We believe that the value of the intraocular pressure as determined by our method is more nearly correct.

In the discussion so far we have assumed that the indentation produced by the tonometer foot plate remains unchanged as various loads are put upon the tonometer plunger, and that the volume change from one load to the next is fully accounted for by the change in volume of the plunger indentation. This is evidently incorrect. As heavier weights are placed upon the plunger the intraocular pressure rises and the foot plate can, therefore, be supported by a smaller area of contact with the cornea. On the other hand as the plunger indentation increases in depth, it increases also in area encroaching on the zone of support of the tonometer foot plate. These two effects should tend, therefore, to oppose one another. In rigid eyes the former effect should tend to predominate, in flaccid eyes the latter; thus the range of variation of ocular rigidity should be somewhat greater, and the range of variation of ocular pressure somewhat less than that determined by our method of measurement.

It would be possible to allow for these effects in the construction of our nomogram. In such a new nomogram the points for identical tonometer-scale readings with different weights would no longer fall upon the same straight vertical line, and the complexity of the nomogram would be considerably increased. Since this would result in only minor changes in the readings it is believed that the extra complexity would not be justified, particularly in view of the fact that the estimation of the volume of the plunger indentation is already admittedly only approximate.

II. Practice

In the previous section we have outlined a method by which a measure of ocular rigidity can be computed from a set of tonometric measurements on a given eye with the use of two or more

different tonometric weights. We have further shown how the intraocular pressure may be computed from the same set of tonometric measurements. Our present task is to discover whether or not clinically significant differences in rigidity can be measured, and whether the intraocular-pressure measurements corrected for variations in ocular rigidity differ in any clinically significant degree from the ordinary tonometric measurements. We have, therefore, made measurements of rigidity and pressure on a large number of normal and abnormal eyes, the results of which will be reported below.

A. Method

1. *Instrument used.* The measurements to be reported were made with a Schiötz tonometer purchased from the Norwegian manufacturer and officially certified as correct by Professor Schiötz. Nevertheless, careful measurements indicated that this instrument differed considerably from Schiötz's standard tonometer. Thus the weight of the tonometer minus plunger and lever arm is 13 grams instead of 12 grams, the weight of the plunger with the lever arm resting upon it and with the appropriate discs is in each case 1 gram greater than in the standard tonometer. The scale intervals which should correspond to 0.05-mm. vertical movement of the plunger correspond in fact to 0.0425-mm. These discrepancies may seem to be quite extraordinary but they do not, in fact, exceed the discrepancies that we have found in many instruments of first-class manufacture that we have tested. This particular instrument had been used clinically for a number of years, and though it was known to give consistently low readings, it had been found a completely reliable clinical instrument when its readings in pathological cases were compared with its readings in normal eyes. In making measurements of rigidity and pressure with this instrument it was, however, necessary to construct a new nomogram similar to that shown in figure 21, but based on the actual weights and scale measurements of the instrument used rather than on the characteristics of the standard Schiötz tonometer.

However, in order to check any discrepancies between the actual instrument used and the standard Schiötz tonometer, we have reconstructed a Schiötz tonometer made by an American manufacturer so as to bring this second instrument as nearly as possible into correspondence with the specifications of the standard Schiötz tonometer. In a considerable number of cases we have made measurements first with one and then with the other instrument. While the scale readings differed markedly with these two instruments, the rigidity and pressure computed from these scale readings by the aid of the appropriate nomograms were found to be in excellent agreement, and showed no systematic deviation whatsoever. We can conclude, therefore, that the theory which we have formulated enables one to make appropriate and correct allowance for wide differences in the details of construction of various Schiötz tonometers.

2. *Method of measurement.* Measurements were made with the patient in the recumbent position after the instillation of two drops of 0.5-percent pontocaine solution. Duplicate measurements were made on each eye with each weight used. In most instances only two tonometer weights were used, but in a few instances tests were made with all four weights. If the duplicate readings did not check one another well, one or more additional readings were taken and the most discordant ones discarded. The average of a pair of duplicate readings with a given weight was taken as the reading for that weight. When the tonometer pointer registered

the pulsation of the intraocular pressure with the cardiac cycle, the average of the systolic and diastolic pressure readings was taken as the reading.

Since the slope of the line on the chart from which rigidity and pressure are to be computed depends on the difference between readings made with different weights, the error in measurement will be greatest when the difference in the weights is least. We have routinely, therefore, made measurements on normal eyes with the 5.5- and 10-gram weights and in cases of elevated tension, with the 7.5- and 15-gram weights. In a few instances, however, we have used all four weights. This latter group of measurements furnishes an additional test for the correctness of our theory, since, if the theory is correct, the readings made with all four weights will determine a set of points on our chart all four of which should lie on a straight line. It was found that these measurements do, in fact, fall on lines as straight as the necessary errors in tonometer-scale readings would allow.

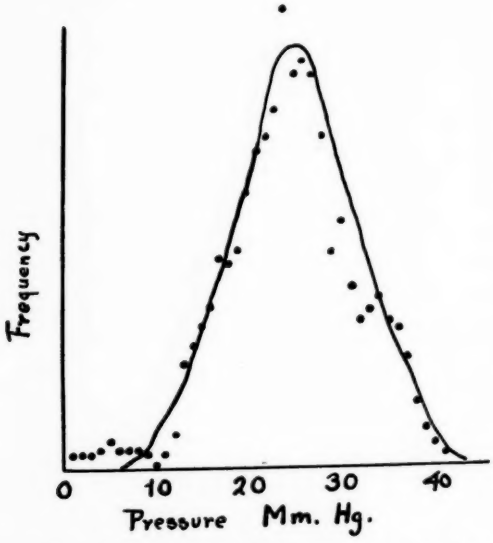

Fig. 23 (Friedenwald). Frequency distribution of various degrees of intraocular pressure in the normal population.

B. Pressure

1. *Normal range of pressure.* In figure 23 the frequency distribution of various degrees of pressure in a group of 500 normal eyes is shown. For this purpose we have classified as normal all cases which did not show glaucoma, detachment of the retina, uveitis, scleritis, keratitis, or old scars of such inflammatory disease, trauma, intraocular hemorrhage, and so forth, but we have included among the so-called normal group all degrees of refraction and also cases of incipient cataract and retinal arteriosclerosis. It will be seen that the frequency distribution of varying degrees of intraocular pressure in this population is a symmetrical one corresponding to a normal frequency curve. The average normal intraocular pressure is found to be 25 mm. Hg with 10 mm. and 40 mm. as the extreme limits of normal variation. Very low values for the intraocular pressure are, as noted above, essentially meaningless. As was indicated in the first section, these values are higher than those determined by the use of the Schiötz scale, but we believe these high values to be freer from systematic error. It must be pointed out, however, that since our pressure determination is computed from the difference between two tonometric readings with different weights, and since the probable error of the difference of two measurements is equal to the sum of the probable errors of the individual measurements, and since an increase in the probable error of measurement produces an increase in the apparent range of frequency distribution, it follows that the apparent range of normal variations of intraocular pressure is considerably greater than the actual normal range of variation of that pressure.

2. *Errors of measurement.* One can roughly compute the effect of errors of measurement on the apparent range of

variation of the intraocular pressure in normal eyes. Let us assume that the probable error in a tonometric reading to be ± one half of a tonometer-scale unit. This corresponds to a probable error of not more than ± 3 mm. Hg in the tonometric measurement with the aid of the Schiötz nomogram in the region of normal intraocular pressure. The same error of measurement in each of a pair of readings with two different weights leads to a possible error of ± 6 mm. Hg in the pressure as computed by the method we have used. From this it would appear that the actual range of variation of intraocular pressure in normal eyes must be well within the limits of the measured range

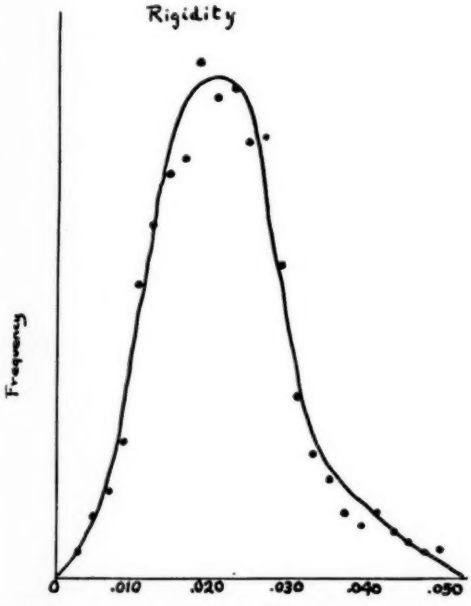

Fig. 24 (Friedenwald). Frequency distribution of various degrees of ocular rigidity in the normal population.

of variation, and that in all probability few, if any, normal eyes have a pressure of less than 15 or more than 35 mm. Hg.

It will be plain from the above discussion that we have, so far, eliminated certain systematic errors in the tonometric measurement as previously carried out only at the expense of increasing the errors of measurement. This is not a very satisfactory state of affairs and it may legitimately be asked whether anything at all is gained in the process. The answer to

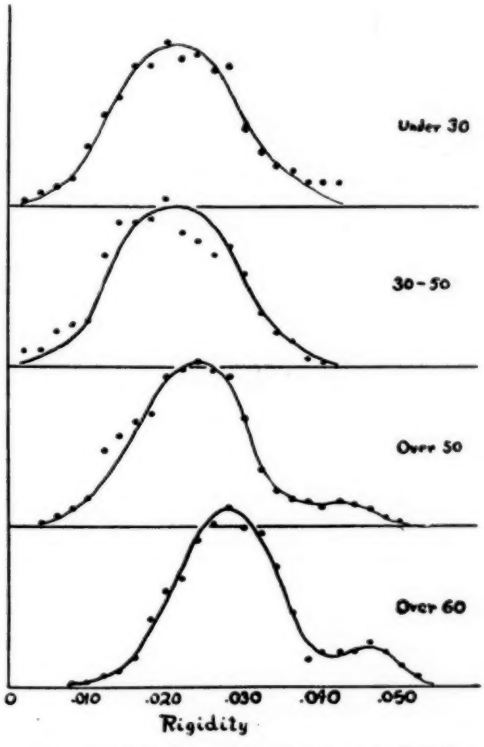

Fig. 25 (Friedenwald). Frequency distribution of various degrees of ocular rigidity in different age groups.

this question is as follows: First, as will be shown below, in spite of the increased uncertainty of measurement, we are able to discover cases of clinically significant variation in ocular rigidity. Second, in view of the actual variation in ocular rigidity, the apparent range of normal variations of ocular tension uncorrected for this factor is even greater than that which we have found. Third, while the neglect of the factor of ocular rigidity introduces errors in tonometry which no refinement in the technique of measure-

ment will reduce, simple errors of measurement can be reduced by an improvement in the technique of measurement, by mechanical refinement of the measuring instrument, or by averaging a number of measurements made, even without improving the instrument or the technique of its use. Finally, it seems far better to know the magnitude of the actual error of measurement rather than to achieve a false complacency over measurements, the reading error of which is small but the intrinsic error of which is great.

C. Rigidity

1. *Relation of age to ocular rigidity.* The frequency distribution of varying degrees of ocular rigidity found in this same group of normal eyes is shown in figure 24. In contrast with the symmetrical-frequency distribution of intraocular pressure it will be seen that the rigidity-distribution curve is asymmetrical or skew, showing a relative excess of cases of high rigidity. The asymmetry in the curve is due almost entirely to the inclusion of old individuals in this group of normal cases. In figure 25 are shown the rigidity-distribution curves for different age groups, all reduced to equal total numbers. The four age groups are 15-30 years, 31-50 years, over 50 years, and over 60 years. No measurements were made on children under 15. It will be seen that the curves for the two younger groups are essentially identical and are symmetrical in form, whereas the average rigidity in the older group is greater, and this group contains practically all of the excess of abnormally high rigidity which was responsible for the asymmetry in the curve of figure 24. It is evident that an increasing rigidity of the ocular coats is characteristic of advancing age. A more detailed examination of the data indicates that this change is first perceptible in the fifth decade, and that it is certainly not uniform for all individuals, since even among persons of over 80 years a considerable number are found whose ocular rigidity is not greater than that of the average young normal adult.

2. *Effect of axial refraction on rigidity measurements.* In choosing as the coefficient of rigidity the ratio of the change in the logarithm of the pressure to the change in the volume of the indentation produced by the tonometric plunger under two different weights, we have up to the present neglected one important factor. Let us suppose that we have under examination two eyes whose ocular coats are actually identical in physical characteristics, but one eye is larger than the other. A given change in volume will stretch the coats of the smaller eye proportionately much more than those of the larger eye and will, therefore, produce a correspondingly greater increment in pressure. This is shown quite clearly in the measurements of the elasticity of the eyeball cited in the first part of this paper. The coefficient of rigidity computed for the different species of animal eyes that have been investigated by various workers, collected in table 1, are greater for animals with small eyes than for animals with large eyes. It is to be expected, therefore, that hyperopic eyes, though otherwise normal, should have coefficients of rigidity greater than emmetropic, and emmetropic eyes greater than myopic. In order to avoid the disturbing influence of age on ocular rigidity, and also to avoid the inclusion of cases of myopia due to sclerosis of the lens, we have omitted all individuals over 50 years old from consideration, and have calculated the average ocular rigidity in relation to different degrees of refraction.

For comparison with the observed variations of rigidity with refraction we have calculated the "expected" variation of rigidity with refraction on the assump-

tions: (1) that the rigidity coefficient varies inversely with the volume; and (2) that the volume of the eye may be estimated from the axial refraction without regard to the variations in corneal and lenticular refraction or to the deviations of the actual shape of the eye from that of a sphere. In figure 26 the observed rigidity variations with axial refraction are compared with the "expected" variations. Considering the crudity of the assumptions on which the calculations of

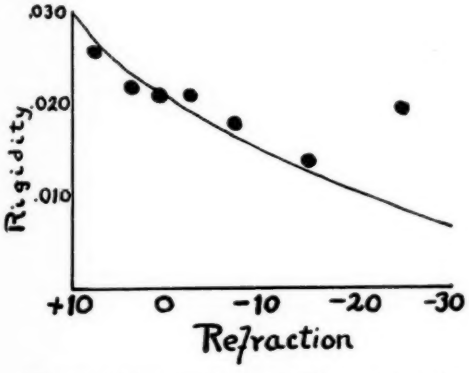

Fig. 26 (Friedenwald). Relation of rigidity to axial refraction. The curve indicates the theoretical values assuming that ocular rigidity varies inversely with the size of the eyeball.

the "expected" rigidity are based, the agreement between the observed and calculated values is remarkably good for all states of refraction except that of the extreme myopic eye. Myopic eyes of over 20 diopters are actually much less distensible than their large volume would lead one to expect. We believe that this deviation is significant. If so, it must indicate that these eyes have been stretched to their elastic limit or at least that their coats are no longer capable of yielding easily to increments of pressure.

3. *Influence of corneal curvature on measurement of rigidity.* The corneal curvatures of all the patients in this group were determined with the keratometer. We have examined the results of the determinations of ocular rigidity in relation to the amount of corneal astigmatism and in relation to the mean radius of curva-

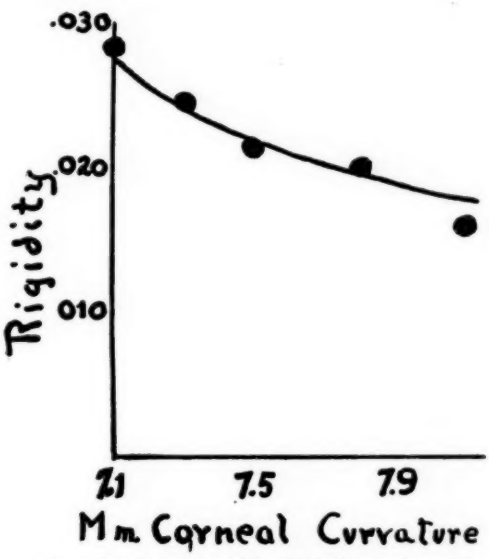

Fig. 27 (Friedenwald). Relation of ocular rigidity to mean corneal curvature. The curve indicates the theoretical values assuming that ocular rigidity varies inversely with the size of the eyeball.

ture of the cornea. The data are shown in table 4 and figures 27 and 28.

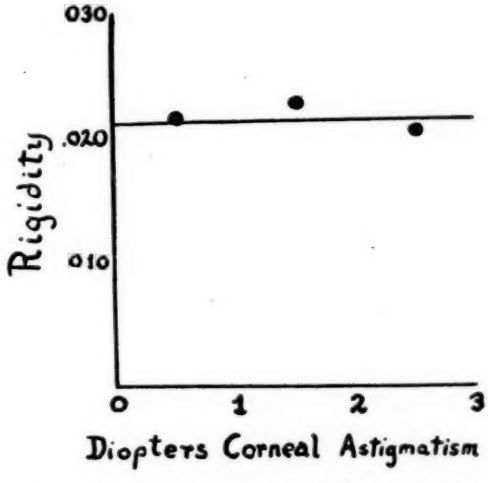

Fig. 28 (Friedenwald). Relation of ocular rigidity to corneal astigmatism. The solid line indicates the average normal ocular rigidity.

It will be seen that varying degrees of corneal astigmatism are not correlated

TABLE 4
RELATION OF CORNEAL ASTIGMATISM TO OCULAR RIGIDITY

Corneal Astigmatism	Average Ocular Rigidity
0 to 1 diopter	.0215
1 to 2 diopters	.0227
2 to 3 diopters	.0203

RELATION OF AVERAGE CORNEAL CURVATURE TO OCULAR RIGIDITY

Mean Radius of Corneal Curvature	Average Ocular Rigidity
7.0 to 7.2 mm.	.0281
7.2 to 7.4 mm.	.0248
7.4 to 7.6 mm.	.0215
7.6 to 8.0 mm.	.0204
8.0 to 8.2 mm.	.0162

with any special trend in the ocular-rigidity measurements. Since variations in corneal astigmatism might well be associated with variations in the elasticity or pliability of the cornea, we have here additional confirmation of the conclusion reached in the first section of this paper; namely, that variations in elasticity or pliability of the cornea do not play a significant role in the tonometric measurement.

When, however, we compare the mean corneal curvature, that is, the average between the curvature in the major and minor axes with the ocular rigidity, we find a definite and strong correlation. Eyes whose corneas have a small radius of curvature have a high coefficient of rigidity, eyes with flatter corneas are more distensible. In order to interpret this finding we must again consider the size of the eyeball. Our findings would indicate that eyes with a small radius of corneal curvature should be on the average small eyes, while eyes with a large radius of corneal curvature should be on the average large eyes. If we assume that the radius of curvature of the eyeball is on the average proportional to the radius of curvature of the cornea, and if we assume, as before, that the coefficient of rigidity is inversely proportional to the volume of the eye, we can compute an "expected" relation between corneal curvature and rigidity coefficient. The result of such a calculation is shown in the figure; again, considering the crudity of the assumptions, the agreement is quite striking.

It must be pointed out that the assumptions we have made in interpreting those two sets of data are not incompatible with one another. It might be objected that if the volume of the eye varies with the radius of corneal curvature, it cannot vary also with the axial refraction in the manner which we have calculated. We are, however, not considering individual eyes, but groups of eyes showing a given axial refraction or a given radius of corneal curvature. Among the highly hyperopic, for instance, the radius of corneal curvature is, on the average, not far from normal, and the axial length of the average among these eyes may reasonably be computed from the axial refraction. Among the emmetropic, on the other hand, there are some whose corneal curvature is unusually high and who achieve emmetropia in view of a corresponding decrease in the axial length of the eyeball. Taking all cases showing a given degree of corneal curvature, the average axial refraction will not be found to differ markedly from that of the whole population. It follows that in these groupings the average volume of the eye may reasonably be correlated with the corneal curvature. The general problem of the relations between corneal curvature, axial refraction, and axial length has been discussed extensively by those, such as Steiger[20] and his followers, who have been concerned with the statistical and genetic aspects of refraction. The suggestions advanced in the present discussion are in full agreement with their findings.

4. *Normal range of rigidity.* From the preceding discussion it must be clear that the normal range of variations of ocular

rigidity cannot be characterized as simply as the normal range of variations of intraocular pressure. If we include in the so-called normals young and old, hyperopic eyes and myopic, relatively flat and relatively deeply curved corneas, we obtain the frequency distribution shown in figure 24, which shows a range of variations from .002 to .055. No genuine significance can be attributed to such figures. If we limit our group of normals to persons under 50 years whose axial refraction lies between +2 and —1, and whose mean corneal curvature lies between 7.5 and 7.9 mm., we shall obtain much more reasonable limits. In this group the average rigidity coefficient is found to be .021, the extremes .006 and .037. This may be compared with the probable error of measurement on the assumption that the probable error of tonometric reading is ±0.5 units of the tonometer scale. Such an error of measurement leads to an uncertainty in the rigidity measurement of ±.006.

It would seem likely, therefore, that the actual range of variations in rigidity of normal emmetropic eyes is much smaller than the range found, and that ocular rigidity is as stable a phenomenon as intraocular tension. Furthermore, it is evident that if we could correct our rigidity coefficient for variations in ocular volume in each case, then we could include among our normals all variations in corneal curvature and all variations in axial refraction except those found in extreme myopia.

The evidence that ocular rigidity is actually subject to relatively small variations in healthy eyes enhances the significance of our findings in regard to the change in rigidity with age, and in extreme myopia. It must be pointed out that both the compressibility of the intraocular vascular bed and the distensibility of the sclera enter into the rigidity determination. We are at present unable to determine which of these factors is responsible for the variations found. In regard to extreme myopia the anatomical evidence of a thinning of the sclera would suggest that changes here are probably the most important factor. In regard to the aged, both factors may be involved. When the intraocular arteries are narrow and rigid, they are less likely to be compressed by an increase in intraocular pressure. On the other hand, the sclera is composed of tissue in many ways similar to that of the coats of the large arteries of the body. It is subject to senile changes in that, in cases of arcus senilis, a diffuse lipoid infiltration is regularly found in the sclera. Often, indeed, the lipoid infiltration of the sclera is much greater than that of the limbal portions of the cornea. Though we have as yet no direct evidence of any relation between these histological findings and the clinical evidence of increasing ocular rigidity in the aged, there is ground for suspicion that the two phenomena may both be evidence of the same changes. Should this prove to be true, it may be that measurements of ocular rigidity will provide us with an index of the degree of senescence of the connective tissue of the body as a whole.

5. *Physiological cupping of the optic disc.* In the course of these studies the observation has repeatedly been made that patients with deep physiological cupping of the optic disc tend to show rather low values in their rigidity coefficient. It has been difficult to assign a numerical value to the size and depth of the physiological cup and no data have as yet been collected with which an accurate measure of this relationship could be established. It remains, therefore, at present merely a clinical impression which it is hoped may be tested in later studies.

6. *Corrected Schiötz nomogram.* Having determined the average rigidity coefficient of normal emmetropic eyes, we are in a position to recompute the Schiötz

scale so that tension readings made with its aid will be accurate, at least in those cases in which ocular rigidity is normal. The average rigidity coefficient found is 0.021. Such a chart is shown in figure 29. It is based on the assumption that the

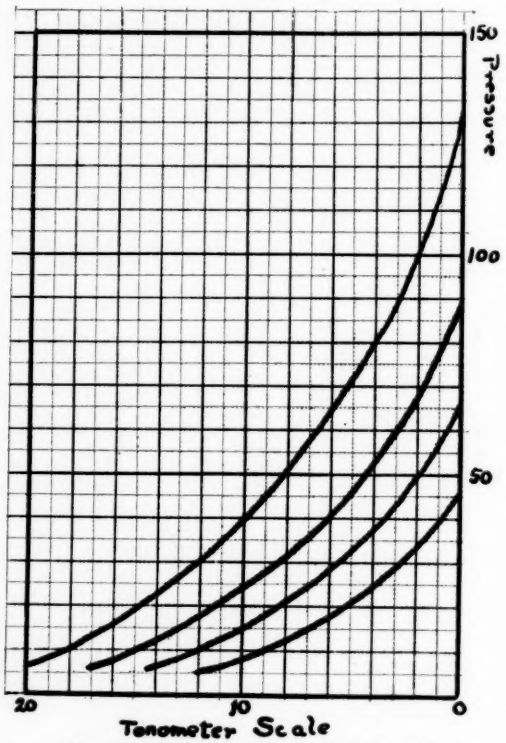

Fig. 29 (Friedenwald). Schiötz chart corrected for average normal ocular rigidity.

tonometer is, in fact, an accurate mechanical replica of the standard Schiötz tonometer. The average normal pressure determined with such an instrument, using this chart, will be found to be 25 mm. Hg. Readings above 35 mm. are to be attributed to either abnormally high pressure or abnormally high rigidity. If measurements on an eye are made with two different weights and the same pressure is indicated on the chart with each weight, the eye may be considered as having normal rigidity and the pressure reading as accurate. If with the heavier of two weights the apparent pressure reading is higher, the eye is abnormally rigid and the actual intraocular pressure is lower than either of the two readings. If with the heavier weight the apparent pressure reading is lower, then the eye is abnormally distensible and the actual intraocular pressure is higher than either of the two readings would indicate.

For those who are reluctant to go through the somewhat complicated procedure of calculating, the pressure and rigidity values which we have developed, as approximations of the true intraocular pressure, corrected for variations in rigidity, may be obtained as follows: Tonometric measurements are made on the eye with two different weights. The reading with each weight determines a point on the corrected Schiötz nomogram. A line may be drawn through these two points. If this line slopes down to the right the eye is abnormally rigid, if it slopes up to the right, the eye is abnormally distensible. The intersection of this line with the pressure axis is an approximate measure of the intraocular pressure.

7. *Ocular rigidity in uveitis.* Thirty-eight measurements were made in 18 cases of uveitis. The average ocular rigidity in this group was .034, distinctly higher than the average normal. This high average was unaffected by the presence or absence of a complicating secondary glaucoma. In fact, when these cases were separated into those with high and with normal pressure, approximately the same value was obtained for the average rigidity in each group. Increased ocular rigidity in intraocular inflammation is not, in the present state of our knowledge, readily interpretable. With the engorgement of the intraocular blood vessels, one would expect an increased compressibility of the vascular tunic and hence a decreased rigidity coefficient. We shall present below evidence that this expectation is borne out, in fact, under some conditions. Since, in spite of this, the rigidity is abnormally high in intraocular inflam-

matory disease, it may be suggested that some of the chemical by-products of inflammation may directly affect the sclera, decreasing its elasticity.

The enhanced ocular rigidity in uveitis is a matter of some clinical importance, for it leads to an unduly high estimate of intraocular pressure in some of these cases, if reliance is placed on the tonometric reading without correction for the lar bed, while long-standing high pressure tends to increase the rigidity of the scleral coat. The usual course of events is as follows: At the beginning of an attack of acute glaucoma, the ocular rigidity is normal or below normal. If the attack has lasted for several days the rigidity is generally found to be elevated. Under the use of miotics the pressure first falls to normal to be followed only after

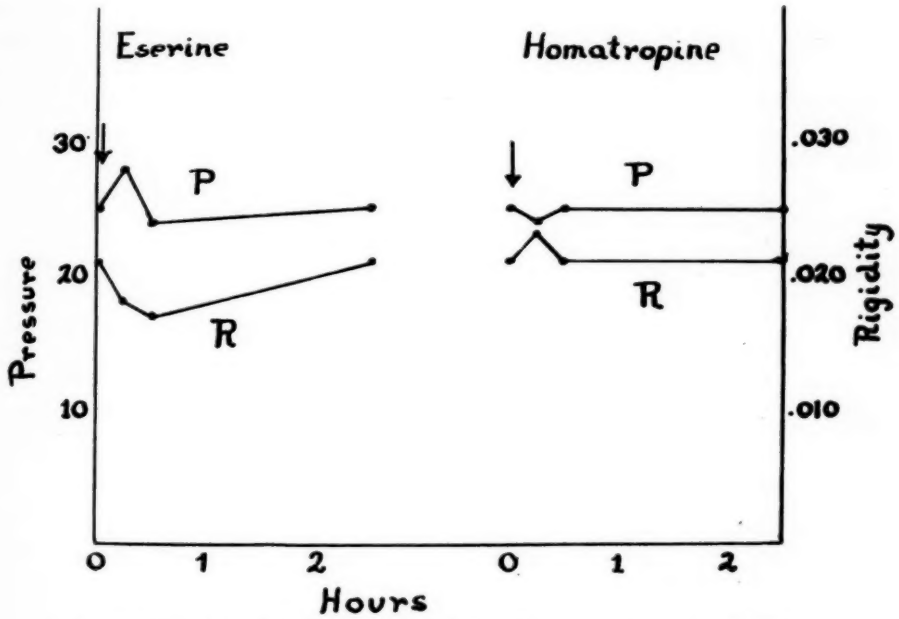

Fig. 30 (Friedenwald). Effect of eserine and homatropine on a normal eye.

abnormal ocular rigidity. Thus, in 6 of the 38 measurements, the results of the measurement with the 5.5 weight would have led erroneously to the diagnosis of secondary glaucoma, whereas the intraocular pressure was actually normal.

8. *Ocular rigidity in glaucoma. (a) Acute glaucoma.* In acute congestive glaucoma the ocular rigidity is very variable, sometimes showing extreme fluctuations during the course of the illness. Apparently the great intraocular congestion in these cases tends to reduce the rigidity coefficient as the result of the increased compressibility of the intraocular vascu-

some days by a normalization of the ocular rigidity. Postoperatively, the same course of events is usually noted.

(b) Chronic noncongestive glaucoma. In chronic noncongestive glaucoma well controlled either by miotics or by fistulizing operations, the ocular rigidity is normal. At times, when there is a large postoperative conjunctival bleb, the rigidity is below normal. In untreated chronic noncongestive glaucoma of long standing, the ocular rigidity is usually high. The result of the application of miotics in these instances is exactly the opposite of that seen in acute congestive glaucoma.

The initial effect of the medication is a marked decrease in rigidity, the pressure remaining elevated or even rising somewhat. After some hours the pressure also begins to fall, and if the case is one readily controlled by miotics, both pressure and rigidity attain normal levels in a short time. Similar effects of miotics, and contrary effects of midriatics can sometimes be demonstrated on normal eyes (figure 30).

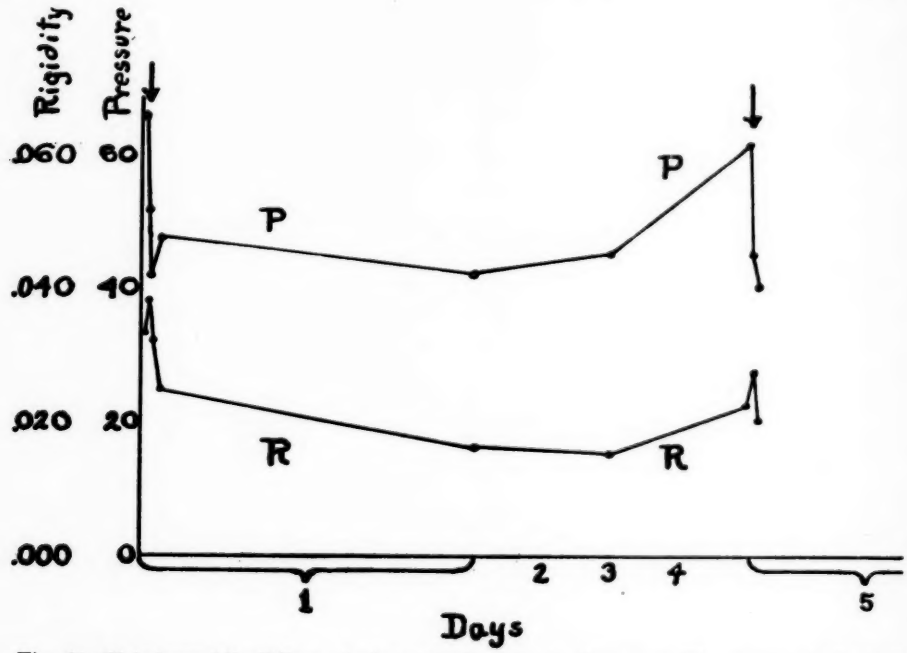

Fig. 31 (Friedenwald). Effect of glaucosan in chronic glaucoma. The arrows indicate the time of administration of the drug. The time scale for the days between the treatments is much compressed.

The course of events after successful operations in these cases is most interesting. Unfortunately, it has not seemed wise to use the tonometer during the first week after operation, but on its first application it has frequently been found that the intraocular pressure is high, sometimes slightly higher than it was before operation, while at the same time the rigidity of the eye was abnormally low. This state of affairs is not of long duration and may often be missed. When the postoperative ocular congestion has disappeared, the ocular rigidity as well as the pressure has returned to normal.

These findings require some comment. It has been pointed out elsewhere that operation in a case of chronic noncongestive glaucoma results in a temporary intraocular congestion with edema of the ciliary body, producing the anatomical equivalent of an attack of acute glaucoma. A marked postoperative drop in rigidity associated with a slight transitory rise of pressure confirms this interpretation of the histological findings.

The fact that the primary effect of miotics in glaucoma is to increase the elasticity of the globe need occasion no surprise. It has long been known that miotics, that is, eserine and pilocarpine, are vasodilators. In view of the evidence, both anatomical and gonioscopic, that there are no peripheral anterior synechia in the early stages of chronic simple glau-

coma, the old hypothesis that miotics affect these cases favorably by simply mechanically freeing the chamber angle can no longer be held. On the other hand, it has been shown that congestion of the vessels connected with Schlemm's canal enhances the rate of absorption of the aqueous fluid.

Results similar to those achieved by miotics can be obtained in lesser degree and more transitory character by the local applications of heat.

The use of glaucosan in chronic noncongestive glaucoma results quite regularly in a most interesting sequence of events (fig. 31). During the first half hour when the ocular tissues are visibly blanched, there is a slight fall in intraocular pressure and a slight but quite unmistakable rise in ocular rigidity. As the phase of secondary congestion comes on, the rigidity falls steeply, usually reaching subnormal levels in 24 hours. The pressure falls slowly following the fall in rigidity and may not reach its minimum until two days after the instillation.

D. Standardization of tonometers.

The results of the clinical investigations reported indicate quite clearly that mechanical refinements in the tonometer which would reduce the error of reading would be of distinct value. The reading errors of the present instrument are so large that reasonably accurate estimates of ocular rigidity and intraocular pressure can be obtained only by averaging the results of repeated measurements. This is a somewhat different goal from that of numerous other investigators who have attempted to standardize tonometers, that is, to check different instruments against one another and reject those that do not give the same readings on a given eye. Difficulties on this latter score can be attributed only to gross carelessness in design and manufacture. We have carefully weighed a number of Schiötz tonometers of standard European and American manufacture, and in no case have we found the weights of the plunger with the lever arm resting upon it to agree within 0.5 gram with its supposed weight in the standard Schiötz tonometer; in no case was the weight of the tonometer minus plunger and lever arm within 1 gram of its supposed weight. However, there is nothing sacrosanct about the particular design chosen by Schiötz, and if the manufacturers can agree to hold their own product rigidly to any reasonable specifications, the Schiötz nomogram and the rigidity coefficient nomogram can be adjusted accordingly.

Similarly, the extension of this method of analysis to instruments other than the Schiötz, but conforming to the Schiötz pattern in regard to the dimensions of foot plate and plunger base, would be quite simple. Tonometers with convex plunger bases such as the Schiötz X tonometer and the McLean tonometer, as now constructed, use only one plunger weight for the whole range of pressure readings. While this adds greatly to the convenience of use, it provides us with no mechanism whereby the effects of rigidity can be distinguished from those of pressure.

III. Summary and Conclusions

The intraocular pressure as measured by the Schiötz tonometer with the aid of the Schiötz nomogram is subject to error due to variations in the rigidity of the ocular coats. For the same intraocular pressure the tonometer reading will be less and the pressure reading correspondingly greater, the greater the rigidity of the eyeball. A study of the experimental work of Schultén, Koster, Schiötz, Ridley, and Clark has led to a simple empirical formula for the relation between pressure and volume change in a given eye.

This formula contains a single numerical constant which we have called the coefficent of rigidity since the value of this constant is greater, the greater the rigidity of the eye. It is shown that this same formula is applicable to tonometric measurements when the pressure is taken as the actual intraocular pressure with the tonometer resting on the cornea, and the volume is taken as the volume of the indentation produced by the tonometer plunger in the cornea.

By using the original experimental data of Schiötz on which Schiötz based his tonometric chart, we have computed the pressure which exists within the eye at each tonometer scale reading for each weight of the tonometer plunger, and also the volume of the indentation corresponding to each tonometer-scale reading. With the aid of these calculations and the empirical formula mentioned above, we have developed a nomogram from which the coefficient of rigidity of an eye may be computed from two tonometric readings with two different weights. Finally, by allowing for the distortion of the cornea due to the tonometer foot plate irrespective of the indentation produced by the plunger, we have developed a method for calculating the true intraocular pressure free from errors due to the rigidity of the ocular coats. For eyes of average rigidity, the pressure so determined is slightly higher than that determined by the Schiötz nomogram, and is more nearly in accord with the experimental results of Wessely and Seidel on living eyes.

The coefficient of rigidity in normal eyes is inversely proportional to the volume of the eyeball, and is correspondingly affected by the axial refraction and the radius of corneal curvature. In the aged and in extreme myopia, the rigidity of the eye is increased. This is likewise the case in intraocular inflammatory disease, and not infrequently gives rise to the erroneous diagnosis of secondary glaucoma. In primary glaucoma the ocular rigidity tends to be increased by long-continued high pressure, tends to be reduced below normal by intraocular congestion. The effect of certain drugs on the ocular rigidity has been studied, and it was found that those drugs which act as vasodilators tend to diminish ocular rigidity, those which act as vasoconstrictors tend to increase ocular rigidity.

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STAPHYLOCOCCIC CONJUNCTIVITIS*

Experimental reproduction with staphylococcus toxin

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Accumulating clinical observations[1] have led to the postulation that staphylococci may produce conjunctivitis, although Axenfeld[2] opposed the idea, and Lindner[3] and Howard[4] showed that the organisms are not epithelial parasites. Therefore this study was designed to determine the clinical action of staphylococcus toxin upon the conjunctiva.

Staphylococcus toxin was prepared by the method of Leonard and Holm.[5] Semisynthetic, semisolid agar was inoculated from five-hour broth cultures of hemolytic Staphyloccus aureus and incubated at 37°C. for 60 hours under a 20-percent oxygen and 80-percent carbon-dioxide tension. Upon removal from the gas chamber the crude toxin was filtered through ordinary filter paper at 4°C. The filtrate was then centrifuged, the clear supernatant fluid removed, and its pH was adjusted to approximately 6.8. A preservative was added and the toxin was stored at 4°C.

The toxin used for inoculation experiments was prepared from five strains of hemolytic Staphylococcus aureus that had been isolated from cases of conjunctivitis or keratoconjunctivitis. These five strains were employed for the preparation of several samples of toxin, in order to determine the constancy of toxin yield under standard conditions and the toxin yield under variable conditions. Under standard conditions the yield was quite constant; however, as reported by Leonard and Holm, increased length of incubation and decreased carbon-dioxide tension resulted in a lower toxin yield.

Potency of the toxin was determined by three methods of titration; that is, hemolytic, dermonecrotic, and lethal. Toxin prepared by the standard method, as described above, caused lysis of rabbits' red blood cells in dilutions of 1:1600 to 1:2000. Upon intradermal injection into rabbits, 0.1 c.c. of a 1:1200 dilution produced necrosis of not less than 0.5 cm. in diameter on the 2d or 3d day. Death was produced in rabbits weighing approximately 2 kilograms in three to five minutes after the intravenous injection of 0.25 c.c. per kilogram, or in 20 to 30 minutes following the intravenous administration of 0.1 c.c. per kilogram. In addition to these factors the toxin probably had a high leukocidin content* although it was not titrated. As yet it has not been analyzed for an enterotoxic factor; however, its potency from ocular sources is comparable to staphylotoxin from other sources in at least the first three of the above-mentioned factors.

The action of this toxin upon the conjunctiva was studied after its instillation into one eye of rabbits, monkeys, and human volunteers, the other eye being used as a control (tables 1-5).

Experimental studies on rabbits

In rabbits there was no immediate irritation nor reaction following the instillation of a drop of the toxin, but after three to four hours congestion of the con-

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* Determined qualitatively by Drs. W. W. Hermann and L. A. Weed of the Department of Bacteriology.

TABLE 1

EFFECT OF STAPHYLOCOCCUS TOXIN ON ANIMAL EYES

Toxin	Rabbits			Monkeys*		
	No.	Conjunctivitis	Keratitis	No.	Conjunctivitis	Keratitis
1 drop	6	6	0	2	2	0
10 drops†	24	24	24	8	8	8

* 7 Macacus rhesus, 3 yellow baboons.
† 1 drop every 5 minutes.

TABLE 2

EFFECT OF STAPHYLOCOCCUS TOXIN ON HUMAN EYES

Toxin	Children			Infants		
	No.	Conjunctivitis	Keratitis	No.	Conjunctivitis	Keratitis
1 drop	4	4	0	5	5	0
1 drop daily:						
a) 3 days	8	8	8			
b) 4 days	8	8	8			
1 drop t.i.d.	8	8	8	27	27	*

* Not examined.

TABLE 3

ANIMAL CONTROLS

Series	Inoculation		Rabbits			Monkeys		
	Toxin	Control	Number	Toxin	Control	Number	Toxin	Control
I	1 drop	nothing	6	+	−	2	+	−
II	10 drops*	uninoculated medium	6	+	−	2	+	−
III	10 drops*	boiled toxin	6	+	−	2	+	−
IV	10 drops*	toxoid	6	+	−	2	+	−
V	10 drops*	toxin-antitoxin (20 drops)	6	+	−	2	+	−

+ = Conjunctivitis or keratoconjunctivitis.
− = No reaction.
* = 1 drop every 5 minutes.

junctival vessels was evident, particularly in the lower fornix. Five to six hours after the instillation, the redness and congestion were increased throughout the entire conjunctival sac, and a yellowish purulent discharge was present (fig. 1). This reaction subsided within 24 hours. No corneal lesions were observed after one drop.

Upon repetition of the drop every five minutes for 10 instillations, there was slight shortening of the incubation period, as measured from the first instillation, and the congestion and redness of the entire conjunctiva increased rapidly. The discharge became purulent and profuse within four to five hours after the first drop and, at this time or shortly thereafter, marginal corneal staining with fluorescein was demonstrable (fig. 2). The staining appeared diffuse, but upon biomicroscopic examination it was re-

TABLE 4

HUMAN CONTROLS

Series	Inoculation		Children		
	Toxin	Control	Number	Toxin	Control
I	1 drop	nothing	4	+	−
II	1 drop daily 3 days	uninoculated medium	4	+	−
III	1 drop daily 3 days	boiled toxin	4	+	−
IVa)	1 drop daily 4 days	toxoid	4	+	−
b)	1 drop t.i.d.	toxoid	4	+	−
Va)	1 drop daily 4 days	toxin-antitoxin (2 drops daily)	4	+	−
b)	1 drop t.i.d.	toxin-antitoxin*	4	+	−

+ = Conjunctivitis or keratoconjunctivitis.
− = No reaction.
* = 2 drops t.i.d.

TABLE 5

HUMAN CONTROLS

Series	Inoculation		Infants		
	Toxin	Control	Number	Toxin	Control
Ia)	1 drop	nothing	5	+	−
b)	1 drop	nothing	3	+	−
II	1 drop t.i.d.	uninoculated* medium	6	+	−
III	1 drop t.i.d.	boiled toxin*	6	+	−
IV	1 drop t.i.d.	toxoid*	6	+	−
V	1 drop t.i.d.	toxin-antitoxin**			−

* 1 drop t.i.d.
** 2 drops t.i.d.
+ = Conjunctivitis or keratoconjunctivitis.
− = No reaction.

solved into closely spaced, superficial, punctate green dots. The corneal pathology disappeared within 24 to 30 hours but the conjunctival congestion and purulent discharge remained for three to four days.

EXPERIMENTAL STUDIES ON MONKEYS

Except in the case of one tame yellow baboon, observations on monkeys were conducted under intravenous nembutal anesthesia, which permitted inoculation and observation for four to six hours under complete narcosis and under semi-narcosis for an additional two to six hours. However, the results with and without anesthesia were comparable.

The instillation of a drop of toxin was not followed by immediate irritation or reaction, but, as in rabbits, the first signs

appeared within three to four hours: There were lacrimation and congestion of the conjunctival vessels which progressed to moderate congestion and purulent discharge within six to eight hours and disappeared entirely within 24 hours. Corneal lesions were not observed after one drop.

After the instillation of 10 drops of toxin at five-minute intervals, the incubation period from the time of the first drop was approximately three hours. However, the discharge and congestion became profuse six hours after the first drop, and marginal corneal staining was demonstrable. The stain appeared diffuse, but biomicroscopic examination revealed innumerable, superficial, punctate, green dots over the entire cornea. The corneal pathology disappeared within 24 hours, but the purulent discharge and congestion persisted three to four days.

Examination of smears of the conjunctival discharge revealed the presence of many polymorphonuclear neutrophilic leucocytes, with a few lymphocytes and epithelial cells but no eosinophilic nor basophilic leucocytes. The only organisms present were a few rods with corynebacteria morphology.

Experimental studies on human volunteers

Observations were conducted on two groups of human volunteers, one on children ranging from six to 16 years of age, and the other on four- to six-day-old infants. Selection of material was made on the basis of a clinically normal conjunctiva and cornea and negative conjunctival cultures. Subsequently, cultures were made from the conjunctiva during the height of the conjunctivitis and after the inflammation had subsided, but no growth was obtained on blood-agar plates.

One drop of toxin instilled into the conjunctival sac of children produced no immediate irritation nor reaction. However, after approximately four hours there was lacrimation and slight congestion of the vessels of the lower fornix in the inoculated eye. The conjunctival inflammation increased rather rapidly for approximately two hours, at which time the children complained of a foreign-body sensation in the inoculated eye and a slight purulent discharge was present. The following morning the lid margins of the inoculated eye were adherent and covered with an encrusted purulent discharge which did not reform after cleansing. The conjunctiva was slightly congested, but this had practically disappeared within 32 hours and was entirely gone after 48 hours. No corneal changes were noted following one drop of the toxin.

In other children a second instillation of toxin was made after 24 hours, but even then there was no immediate reaction nor irritation; however, there was an intensification of the symptoms and signs produced by the first drop, but no corneal pathology. After the third daily instillation of one drop of toxin, corneal pathology was noted within six to 10 hours, or at the height of the intensified conjunctivitis. The cornea showed superficial, punctate, marginal opacities which stained green with fluorescein. The majority of these staining areas had disappeared 24 hours after the third drop but in those children who received a fourth daily drop the disturbance of the corneal epithelium was much more pronounced six hours after that drop than it had been after the third drop. This condition persisted for 24 to 30 hours. The intensified conjunctival congestion continued for approximately three days following the fourth instillation, although the purulent discharge disappeared within approximately two days.

Two groups of four children were inoculated with one drop of toxin into one

eye at 1:00 p.m., 4:00 p.m., and 9:00 a.m. the following morning. Approximately six hours after the second instillation there were observed numerous superficial, punctate, marginal corneal opacities which stained with fluorescein. Between four and six hours after the third instillation the cornea took a diffuse superficial green stain which could not be resolved into punctate areas with the biomicroscope and slitlamp. In these cases each child showed several punctate subconjunctival hemorrhages, a slight amount of excoriation of the skin at the lateral canthus, and some dusky edema of the lower lid of the inoculated eye; these latter manifestations disappeared within 24 to 48 hours after the last instillation, although the conjunctival congestion and punctate hemorrhages persisted for three to four days.

In some observations, made on four- to six-day-old infants not included in the tables, it was noted that practically the entire drop of toxin was expelled as soon as the infants' lids were released and that almost no irritation developed in the conjunctiva after such an exposure to the toxin. Therefore a drop of toxin was instilled into the conjunctival sac and the lids held open for approximately one minute. This resulted in moderate conjunctival congestion and slight purulent discharge in from four to five hours, both of which disappeared within 12 to 24 hours. Repetition of the inoculation after 24 hours did not increase the amount nor duration of the reaction. Five series of infants were subjected to this latter type of instillation into the right eye, at 8:00 a.m., 12:00 m., and 4:00 p.m. Four hours after the first instillation, there was a slight conjunctival congestion which became diffuse, more pronounced, and within six to seven hours after the first drop was accompanied by a purulent discharge. At the time of the third drop the lid margins were adherent and covered with an encrusted purulent discharge. Between 12 and 16 hours after the first drop, that is, four to eight hours after the third drop, dusky edema of the lids and irritation of the skin in the region of the lateral canthus were noted. Twenty-four hours after the first drop, the lid margins were adherent and covered with a purulent discharge; the conjunctival congestion was intense, punctate subconjunctival hemorrhages were present, and the irritation at the lateral canthus had developed into a superficial excoriation, but the edema of the lids had diminished. The edema and purulent discharge disappeared within 48 hours after the first drop, the conjunctival congestion and superficial excoriation of the lateral canthus lasted 72 hours, but the punctuate hemorrhages persisted for another 24 to 48 hours. This method of instillation reproduced the type of ophthalmia of the newborn so commonly caused by the hemolytic Staphylococcus aureus.[1a]

Smears of the conjunctival discharge were made at the height of the inflammation to determine the nature of the cellular reaction. The secretions were composed almost entirely of polymorphonuclear neutrophilic leucocytes with some small lymphocytes. No eosinophilic nor basophilic leucocytes were found. Prolonged study of these smears revealed only an occasional rod-shaped organism with the morphology of corynebacteria.

Controls

As shown in the tables, five series of observations were made on each experimental group. In each series one eye was inoculated with toxin while the opposite eye was used as a control. In the first series the control eye was not inoculated. In the second series the control eye was treated with an equal dosage of culture medium which, except for inoculation

with staphylococci, had been subjected to the same procedures as those used in the preparation of toxin. An equal number of drops of boiled toxin was used as a control in the third series of experiments: the toxin was maintained at 100°C. in a water bath for 45 minutes and, before use, the destruction of its toxin properties was tested by intravenous inoculation of six rabbits; three were injected with 0.25 c.c. per kilogram of body weight and three were injected with 0.5 c.c. per kilogram, but all survived without signs of injury.* An equivalent amount of commercial staphylococcus toxoid was instilled into the control eye in each experiment of the fourth series. A toxin-antitoxin mixture was instilled into each control eye of the fifth series; two drops of the toxin-antitoxin mixture were instilled at one-half-minute intervals into the control eye in each case in order to expose the conjunctiva to the equivalent amounts of toxin. The effectiveness of the neutralization of the toxin by the antitoxin was tested by the intravenous inoculation of rabbits; three were inoculated with 0.5 c.c. of the mixture per kilogram of body weight, and three others with 1.0 c.c. per kilogram, but all survived without signs of injury.*

Neither conjunctivitis nor keratoconjunctivitis was produced in any of the control eyes (fig. 3).

Conclusions

1. Staphylococci of the hemolytic aureus type isolated from ocular sources are capable of producing toxin potent in lethal, hemolytic, and dermonecrotic factors.**

2. Toxin of this type is capable of producing a conjunctivitis and a keratoconjunctivitis after instillation into the conjunctival sac of rabbits, monkeys, baboons, and man. This superficial punctate keratitis is similar to that so frequently observed in clinical cases of staphylococcic conjunctivitis.

3. The action of the toxin probably accounts for the production of conjunctivitis by staphylococci, even though they are not epithelial parasites in the sense of Lindner and Howard.

Addenda

Since reading this paper, Dr. Phillips Thygeson has informed the author that Morax and Elmassian[6] reported similar conjunctival changes following the instillation of staphylococcus toxin.

* These rabbits were observed for one month after the inoculation.

** Although not titrated leukocidin was also produced by the strains studied.

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Discussion

Dr. F. H. Verhoeff: I would like to ask about the cultures.

Dr. Allen: The cultures were taken before the experiments were made at the height of the conjunctivitis and after the conjunctivitis had subsided. In each case they were negative. The human volunteers, of course, were selected on the basis of negative culture to begin with.

Dr. H. O. Sloane: Were those cases treated afterward, and how long did they last?

Dr. Allen: No treatment was necessary since the conjunctivitis subsided when the drops were discontinued. The inflammation was produced by the toxicity of the material and not by an infectious agent. Therefore, as soon as the toxic material was removed, the conjunctivitis began to heal.

Dr. T. D. Allen: Does the eye become allergic to the toxin so that later the reaction comes on more quickly and in greater degree?

Dr. Allen: We have had no occasion to repeat our experiments at an interval long enough to permit an answer to that question. The controls that were run and the type of cellular reaction in the conjunctivitis, I think, would eliminate the possibility that the primary reaction was allergic.

Dr. E. V. L. Brown: Did you proceed to make the transfer to the interior of the eye?

Dr. Allen: No, we have only started this problem. We intend to continue and enlarge upon it, and that is one of the things we hope to be able to study.

A PRELIMINARY REPORT OF A CASE OF KERATOCONUS, SUCCESSFULLY TREATED WITH ORGANOTHERAPY, RADIUM, AND SHORT-WAVE DIATHERMY*

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Dorland defines keratoconus as "a cone shaped deformity of the cornea." This condition is found predominantly in young individuals, particularly in females. The affection begins to develop, in most cases, simultaneously with or soon after puberty. The cause is unknown.

Investigators have recognized for many years that it is associated with some constitutional predisposing factors. The more common disturbances are anemia, hypothyroidism, low blood pressure, endocrine imbalance, and so on. Jackson,[1] A. Knapp,[2] Török and Redway,[3] and others have stressed this fact. The most common condition found in the cases reported has been a low basal metabolism.

Various theories have been advanced as to the cause of keratoconus; for example it has been ascribed to heredity, endocrine imbalance, syphilis, constitutional degeneration, and so forth. Certain of these factors have been found in most of the cases reported. However, at the present time, it is impossible to say definitely that one factor or another is the cause of the condition.

Since cases of keratoconus occur, how are we going to treat them? Three methods of attack have already been suggested; namely, medical, surgical, and by contact glasses. No one treatment alone has been adequate. We plan to suggest a fourth procedure, physical therapy combined with medical treatment. This method has proved most successful in our one case, and justifies this preliminary report.

The medical approach need not be described, as it is obvious that an anemia, hypothyroidism, or syphilitic infection must be corrected if a satisfactory result is to be expected.

As to surgery, many operations and procedures have been devised and suggested. Herman Knapp[4] in 1892 described his method of treating six cases with the galvanocautery. He stressed the protracted healing and the collapsing and refilling of the anterior chamber after perforation of the cornea. Later he did not perforate the cornea, but used the galvanocautery repeatedly, until the desired scarring result was obtained.

Many types of operations have been devised. Iridectomy, sclerotomy, partial excision of the cornea, cautery of the apex of the cone followed by tattooing the scar, among others, have been advocated. Each procedure in itself is a serious one, and not without risks of causing severe iritis, uveitis, or even panophthalmitis. Time does not permit description of the numerous operations suggested by the various authors.

The third method of helping these unfortunate patients is through the use of contact glasses. In most cases the vision is improved, but the primary deformity is not corrected. O'Rourke,[5] Sitchevska,[6] and others have reported favorably on this form of treatment.

Before discussing the rationale of the treatment used by the authors, a brief résumé of the underlying pathology of the cornea should be given. The primary factor in keratoconus is a change in the strength and consistency of the cornea.

* Read before the Association for Research in Ophthalmology, Eighth Scientific Meeting, at Atlantic City, N.J., June 8, 1937.

The cornea begins to bulge forward in the shape of a cone. As the condition progresses, there are changes in the parenchyma of the cornea, which interfere with the passage of light. To the examiner, in advanced cases, the point of the cornea shows an opacity.

Von der Heydt[7] studied seven cases with the slitlamp. Two showed typical opacification and vertical striping in the middle and deep parenchyma of the cornea. He also found the nerve fibers decidedly thickened. In the most advanced cases, Descemet's membrane was ruptured. Fleischer's ring could be seen in two of the cases.

Vogt[8] has found similar changes in the middle and deep parenchyma of the cornea. The thickening of the nerve fibers is also characteristic.

In 1931, two of us (H. L. H. Sr., and Jr.[9]) reported the results of surgery and radium in 23 cases of corneal opacity. One of the cases in particular, that of A. J. B., showed a marked improvement in the shape of the staphyloma following the use of radium.

Lane[10] reported before the American Medical Association, in 1926, the beneficial action of radium on opacities of the cornea. Two of the authors (H. L. H., Sr., and Jr.[11]) reported the results of the use of radium in lesions of the cornea in 1934, and concluded that radium can be used beneficially in four conditions of the cornea; namely, (1) trachoma with severe pannus, (2) maculae and denser opacities of the cornea, (3) extreme leucomas of the cornea combined with surgery, (4) postoperative pterygia.

Sanford Withers[12], in 1924, made a very interesting observation and suggestion in regard to the treatment of keratoconus, but we have been unable to find in the literature any references to indicate that anyone has tried to carry out his suggestion. He stated: " . . . the standard treatment of this condition (keratoconus) is understood to be the use of cauterizing measures to produce a scar-tissue contracture of the cornea. With this in mind, would it not be possible to produce such contractures without as dense scarring (as is produced by the cautery) by means of the beta ray application to the projecting cone? The scars resulting from radium applications to the cornea have been found to be uniformly less opaque than scars from escharotics or cauterizations. Such radium scarring should then be preferable to the more dense scars."

Lane[13] and others have shown definitely that radium has a beneficial action upon corneal scars, causing them to diminish in size. Meyer Wiener[14] follows his resections of the cornea with the application of the X ray and finds that the results are similar to those obtained with radium.

The authors realized that all of the procedures hitherto reported for the treatment of keratoconus offered little or no hope for the patient. With the knowledge that the condition is due primarily to some unknown general constitutional factor and that the changes in the cornea are due to a weakness of the corneal substance with opacification in the middle and deeper layers, we decided to see what results could be obtained by combining the general medical treatment with stimulation of the cornea. We were reasonably sure that the use of radium would help clear the opacity at the apex of the cone. Any treatment that would stimulate and improve the nutrition to the cornea could scarcely do harm. It was therefore decided to combine the use of radium with daily treatments of short-wave diathermy.

Case report

The details and the result of the treatment follow:

L. L. H., a white female, aged 18 years,

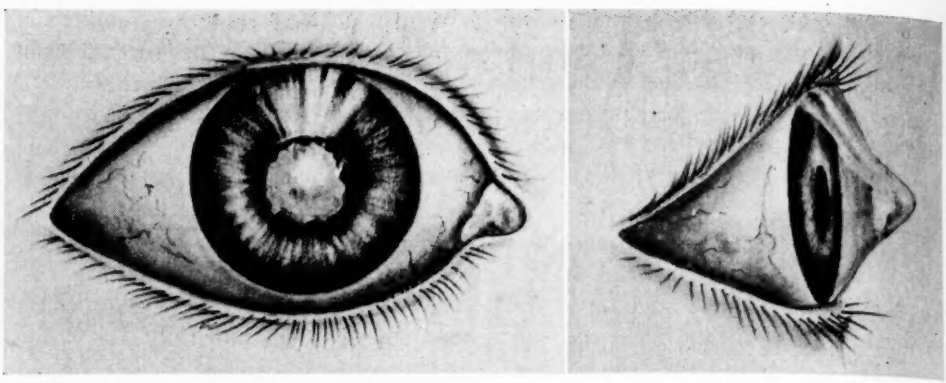

Fig. 1 (Hilgartner, Hilgartner, and Gilbert). Front and side views of right eye on January 2, 1937. Vision = ability to detect hand motion at one foot.

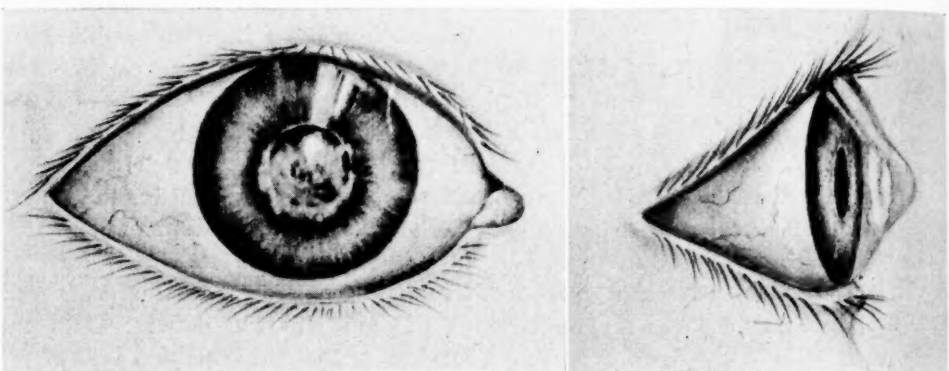

Fig. 2 (Hilgartner, Hilgartner, and Gilbert). Front and side views of right eye on January 9, 1937. Vision improved to ability to detect hand motion at five feet.

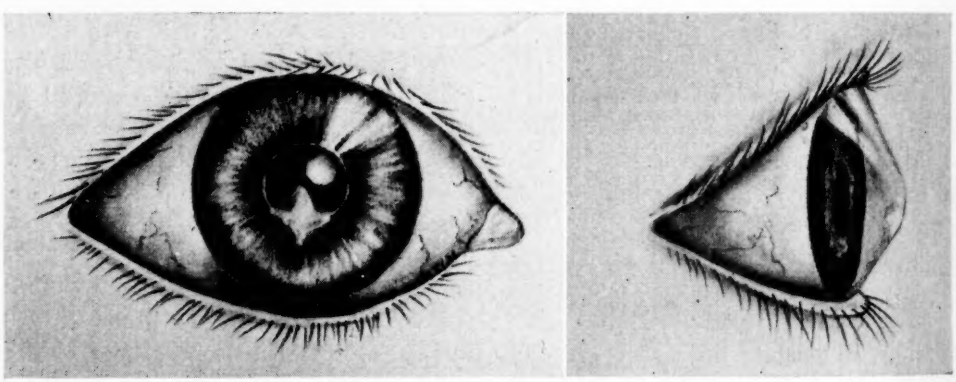

Fig. 3 (Hilgartner, Hilgartner, and Gilbert). Front and side views of right eye on February 1, 1937. Vision = 20/200.

was first seen on January 2, 1937, complaining of a sudden blurring of the vision in the right eye.

The patient stated that on the night before, she had suddenly noticed a marked blurring of the vision in the right eye. The eye felt as though there were something in it. Vision in the right eye had

been impaired for several years, but even though objects were distorted, she could see with it. Now, the only way she could see was from the side. No pain was associated with the sudden blurring of vision.

The patient gave a long history of allergy and sensitivity to various foods. ago by an oculist in another city. The patient had had the usual childhood diseases. Menstruation began at the age of 12 years and the periods have been normal except for some dysmenorrhea. The patient had been delivered with forceps.

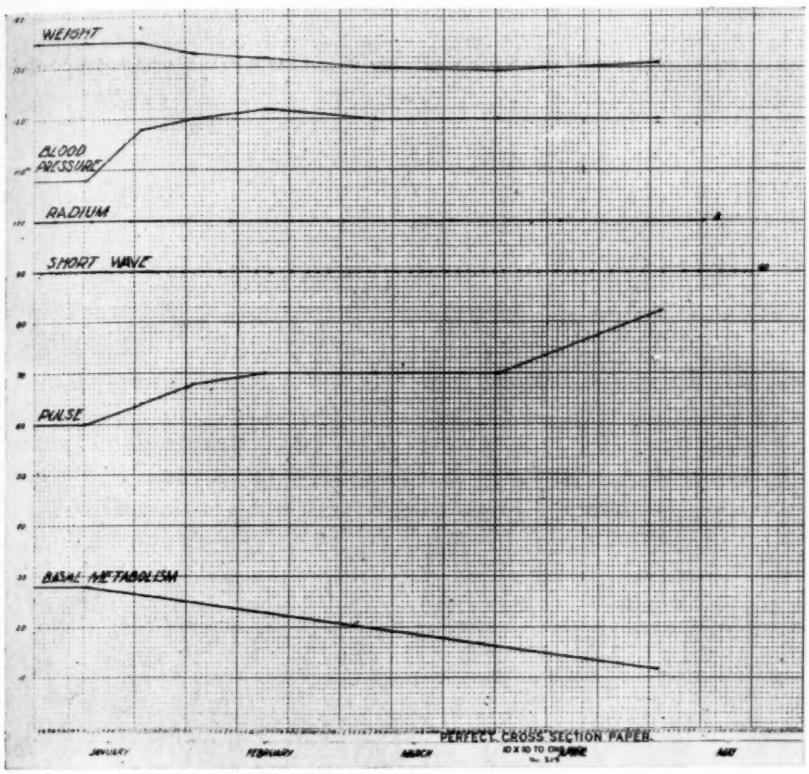

Fig. 4 (Hilgartner, Hilgartner, and Gilbert). Therapy and progress chart.

This sensitivity has existed since early infancy. Treatment for many years has been directed not only to relieving the sensitivity to various foods, but also to correcting hypothyroidism.

The patient stated that since she was two yeras of age, she had had a dry, scaling, itching skin condition which had been labeled allergic eczema. For years she had had a feeling of physical and mental lethargy, some nervousness, and a tendency to be overweight. The diagnosis of early keratoconus was made several years

Mother and father were living and well. Several brothers and sisters were all normal and well. No history of any similar eye condition in any other member of the family could be recalled.

Ocular examination: Vision in the right eye was the ability to discern hand movements at one foot; in the left eye 20/65 with correction.

Right eye: The cornea projected out forming a typical cone; the apex was not exactly in the center, but had been pushed downward a little. A marked opacification

of the apex of the cone extended back about 3 mm. The changes were in the substantia propria. No Fleisher's ring was observed. The iris reacted well to light. The sclera was normal. There was no pericorneal injection. The fundus could not be seen. Tension to fingers was normal.

Left eye: The cornea showed a slight conical formation, but not of sufficient amount to interfere with the school work of the patient. The iris and sclera were normal, as was also the fundus.

The patient was immediately started on daily short-wave diathermy treatments, using dionin and mercurochrome drops at home (fig. 4).

The first radium treatment was given on January 5, 1937. A 10-mg. platinum needle was passed for three minutes over the cornea at a distance of 2 mm. (according to the method of Lane). The second and third radium treatments were given on January 12th and 19th for four and five minutes, respectively. Since then radium has been given every three or four weeks for five minutes.

Short-wave diathermy was used daily until February 1st (being omitted on radium-treatment days). After February 1st short-wave diathermy was used every other day for a month. Since then it is being given twice a week.

The report of a physical examination given on January 11, 1937, by Dr. J. T. G., is as follows: Temperature 98°F., pulse 60, blood pressure 108/80, weight 135 lbs.

General: The patient is a young adult, 18 years of age, well developed, and well nourished.

Head and neck: The condition of the eyes has been noted. The tongue is coated, the teeth are in very good condition. The tonsils have a tag on each side. The nose is normal; the sinuses are clear to transillumination.

Respiratory: The expansion of the chest is ample and equal on the two sides. No abnormal signs are elicited on physical examination. On fluoroscopic examination, both lungs are found to be clear. The cardiovascular pulse is 60, fairly strong, and regular; there is sinus arhythmia, the arteries show an elasticity normal for a girl of her age. The heart and aorta, as outlined by percussion and as seen under the fluoroscope, appear to be normal in size, shape, and position. The heart sounds are normal.

Abdomen: The liver and spleen are not palpable. There are no masses and no points of tenderness. Peristalsis is normal as is also the rectum.

G.U.: Negative for pathology. There is a slight leucorrhea—smears were taken.

Nerves and mental: Normal reflexes are present, no abnormal ones being noted. The mentality seems to be that of an average young adult.

Extremities: Normal.

The face, neck and body are covered with an eruption which gives the skin a rough, thickened appearance.

Blood Examination: Red cells 4,670,000, hemoglobin 90 percent, white cells 11,100, polymorphonuclears 63, lymphocytes 36, monocytes 1.

Vaginal smear: Some pus cells, otherwise negative.

Urinalysis: Clear amber color, acid reaction, very faint trace of albumen, a few urates, an occasional red blood cell, many epithelial cells, some mucus.

The Wassermann reaction in both blood and Kahn tests, negative.

X ray: a flat plate of the abdomen was negative.

Because of the slowness of the pulse, the low blood pressure and lack of energy, a basal-metabolism test was made. Result: Minus 28.

Treatment. The patient was put on one grain of desiccated thyroid substance

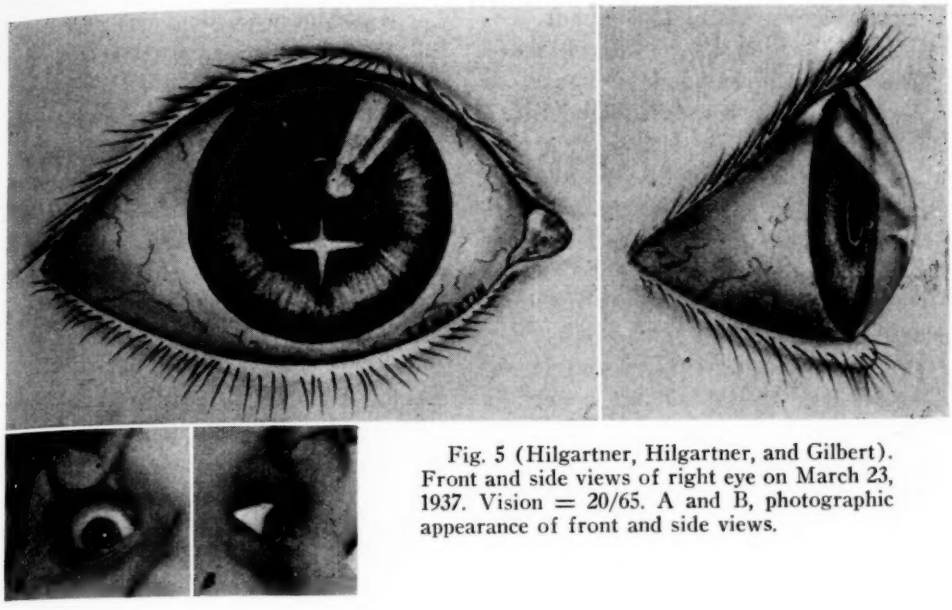

Fig. 5 (Hilgartner, Hilgartner, and Gilbert). Front and side views of right eye on March 23, 1937. Vision = 20/65. A and B, photographic appearance of front and side views.

daily on January 12, 1937. The diagnosis of keratoconus associated with hypothryoidism seemed to be obvious. After 10 days the blood pressure had risen to 118/78, the pulse to 64. The weight remained as before. The dosage of thyroid was increased to 1½ gr. daily.

On February 1, 1937, the blood pressure again showed an increase, to 120/80 the pulse to 68. The weight had

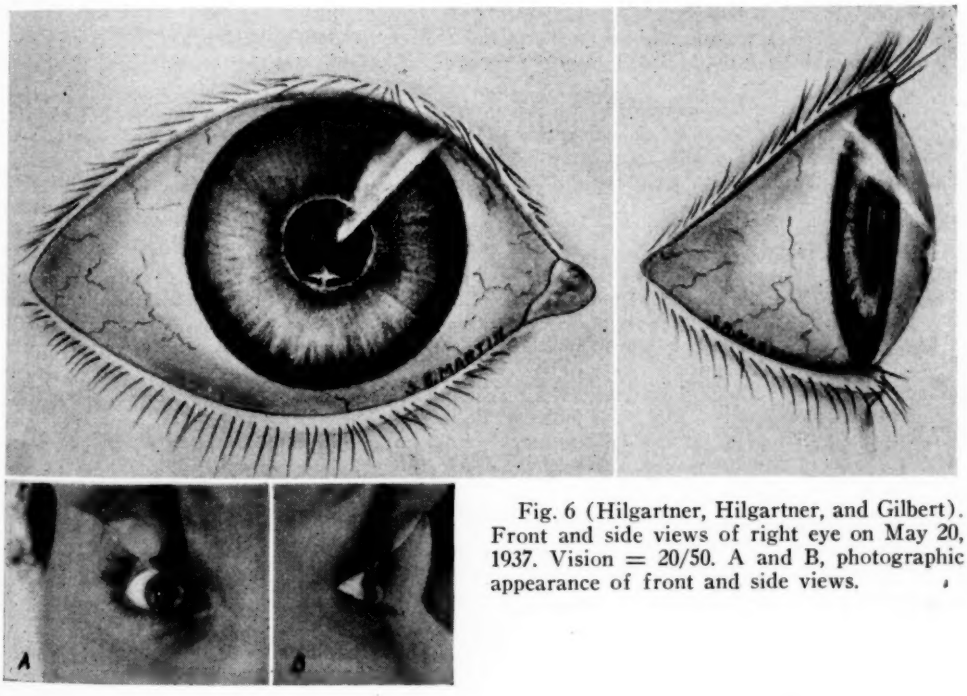

Fig. 6 (Hilgartner, Hilgartner, and Gilbert). Front and side views of right eye on May 20, 1937. Vision = 20/50. A and B, photographic appearance of front and side views.

dropped two pounds to 133 pounds. The patient was put on 2½ gr. thyroid daily.

The corneal opacity had decreased in size, its conicity somewhat diminished (fig. 3). Vision in the right eye had increased to 20/200 without correction; in the left eye to 20/49 with correction. Two weeks later the blood pressure was 122/80, the pulse 70, and the weight 132 lbs. The administration of thyroid was increased to 3 gr. daily.

On February 19, 1937, vision in the right eye was 20/100 without correction.

On March 8, 1937, the blood pressure was 120/80, the pulse 70, the weight 130 lbs. The dosage of thyroid was increased to 3½ gr. daily. Vision in the right eye, fifteen days later, was 20/49 — 2 with correction.

On April 1, 1937 the patient's weight had dropped to 129½ lbs. the blood pressure was 120/80, the pulse 70. The dosage of thyroid was increased to 4 gr. daily.

The patient has had no nervousness and felt progressively improved since thyroid medication was begun.

A basal metabolism test was made May 2d; its result + 12. On the same day the pulse was 82, the blood pressure 120/80, the weight 131 lbs. The general condition on this date seemed to be very satisfactory and the patient expressed herself as pleased with the improvement in her sense of well-being.

Conclusion

The authors concede that an individual case report is not conclusive. They believe, however, that the almost phenomenal response to the described treatment justifies an early preliminary report.

It is to be hoped that this procedure will be used in other cases of this nature, and that similar results will be obtained, thus eliminating the hazard of surgery and other mutilating procedures.

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Discussion

Dr. Verhoeff: To what do you attribute, or what changes do you think were induced in the cornea to produce this tremendous change?

Dr. H. L. Hilgartner: The explanation that I have tried to give to this is that the short-wave diathermic current has improved the circulation to the cornea. Whether there is any electrical effect there, I do not know. We do know that short-wave diathermy does cause a vasodilatation of the capillaries if short treatments are given.

If longer treatments are given we get a stasis, and of course with protracted treatment the point is reached where necrosis and severe burns result.

Dr. Verhoeff: Does it show that the apex of the cornea became thicker?

Dr. Hilgartner: My impression has been that there was not a great thickening in the apex.

Dr. Olga Sitchevska: Which part of the treatment did you consider most effective?

Dr. Hilgartner: As I said in the early part of my talk, the great change occurred in the first week, and during that time the patient had received nothing but short-wave diathermy, the dionin, and mercurochrome. I feel that the diathermy has been the important factor in her improvement.

Dr. Verhoeff: Do you think the total area of the cornea has changed or just the shape of the cornea?

Dr. Hilgartner: I don't think the total surface area was changed at all, sir.

Dr. Verhoeff: Just the shape?

Dr. Hilgartner: Yes.

A STABLE NONIRRITATING SOLUTION OF PHYSOSTIGMINE SALICYLATE*

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San Francisco

The irritating qualities of solutions of physostigmine salicylate (eserine) upon the conjunctiva are well known and limit the usefulness of this drug as a therapeutic agent in the treatment of glaucoma. The conjunctival irritation which results from the use of the solutions of eserine may be due to the drug itself, to the vehicle used to dissolve the drug or to a combination of the two.

Lipschütz[1] showed that the irritating qualities of solutions instilled into the conjunctival sac depended to a large degree upon their hydrogen-ion concentration (pH). He studied the irritating qualities of physiological saline solutions upon the conjunctiva when adjusted to various hydrogen-ion concentrations and found that the solutions which were near the neutral point produced no irritation; that the solutions which were slightly alkaline (pH 8 to 9) or slightly acid (pH 6.6 to 6.3) produced a slight irritation; and that the solutions which were more acid than pH 6.3 produced severe burning and congestion. My own experience with buffer solutions of various hydrogen-ion concentrations (using a boric-acid–sodium-tetraborate buffer system, and also a phosphate buffer system) leads me to believe that the instillation into the eyes of solutions which are within the limit of pH 6.2 to 7.8 will not produce signs or symptoms of irritation in the conjunctiva. Above or below this range of hydrogen-ion concentration the patient notices a stinging sensation and the conjunctiva becomes congested.

Drs. Gifford and Smith[2] studied the hydrogen-ion concentration of various ophthalmic drugs that were prepared with distilled water as the vehicle and found that most of these solutions had an acid reaction of pH 6.0 or lower. They also found that most drugs were absorbed more efficiently through the cornea when used in a slightly alkaline solution, and that the solutions of those drugs in which their alkaline buffer was used as a vehicle were less irritating than the same solution prepared with physiologic saline. Their boric-acid–sodium-carbonate buffer solution inhibited the growth of molds, which made a preservative unnecessary. (Preservatives are added to many of the solutions of drugs when prepared with distilled water or normal saline.)

The buffering capacity of the boric-acid–sodium-carbonate buffer system is not great; therefore, a boric-acid–sodium-tetraborate buffer system and a phosphate buffer system were tried as a vehicle for ophthalmic drugs. The boric-acid–sodium-tetraborate buffers have a range from pH 6.6 to 9.2 and prevent the growth of molds. The phosphate buffers have a range from 5.4 to 8.2. The latter buffer system has the advantage of introducing no foreign ions into the conjunctival sac (the phosphate salts are very important in maintaining the constant pH of the blood stream), and of having a greater buffering capacity than the boric-acid-tetraborate buffer, but it has a disadvantage in that it does not inhibit the growth of molds, which makes it neces-

* From the Department of Ophthalmology, Stanford University Medical School and Children's Hospital. Read before the Pacific Coast Oto-Ophthalmological Society at Salt Lake City, May 26, 1937.

sary to add some fungicide in order to keep the solution clear.

The irritating qualities of solutions of physostigmine salicylate can be reduced to a minimum by dispensing the drug in a buffered solution adjusted to a pH that lies between 6.2 and 7.6. Eserine in solution is unstable, especially in the more alkaline solutions; therefore, it is recommended that an acid buffer be used.

This lack of stability of solutions of physostigmine salicylate, which results in a change in the color of the solutions, is probably an oxidation process, for it can be controlled by adding a reducing agent to the solutions. Although this color change, so long as it is not extreme, does not affect the miotic action of the solution of eserine upon the pupil, it may be shown by more delicate tests to reduce the efficiency of the physostigmine solution as a parasympathetic stimulator. This change in color of the eserine solution does, however, psychologically disturb many patients. It is not uncommon for a patient to come into the office and state that he discontinued his drops because the solution had become a red color and that he felt the drops had spoiled and had hurt his eyes. This is, of course, fallacious, but does not seem so to the patient, for frequently the conjunctiva has become red and irritated at about the same time that the eserine solution has turned a noticeable pink; he, therefore, associates the conjunctival irritation with change in the color of his drops.

Sodium formaldehyde sulfoxylate is a harmless, nonirritating reducing agent which will control the development of a color when added to a solution of eserine to a concentration of 1:5,000. The efficiency of this reducing agent in the prevention of the development of color in a solution of eserine is at a maximum when used in a phosphate buffer solution at pH 6.2.[3] Solutions of 1-percent eserine in a phosphate buffer solution at pH 6.2, to which sodium formaldehyde sulfoxylate to a concentration of 1:5,000 has been added, have been kept for six months without developing a pink color.

The physostigmine-salicylate solutions that are now being given a clinical trial are made up in 0.5-percent and 1-percent strength in phosphate buffer solution to which sodium formaldehyde sulfoxylate to a concentration of 1:5,000 has been added. The concentration of the phosphate salts in the buffer solution are such as to make the final mixture isotonic with human red blood cells.

This solution keeps quite well in that it remains colorless. It is nonirritating to the conjunctiva, even when used frequently (three to five times daily) over a long period of time, and stings very little when dropped into the eye. It has been effective in producing miosis and in reducing the tension in cases of glaucoma which would not respond to treatment with solutions of pilocarpine. The pain that is experienced by some patients, the result of the stimulating action of eserine on the sphincter muscle of the iris, is not diminished.

Unfortunately, it is impossible for most druggists to compound this mixture, for it is important that the various constituents be pure, that their concentration be accurate, and that the hydrogen-ion concentration be accurately adjusted to pH 6.2—else the solution will not keep.*

490 Post Street.

* Eserine solution prepared as outlined above may be obtained from the Associated Physicians Laboratory, Flood Building, San Francisco, California.

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SPHEROPHAKIA, LUXATION OF LENSES, AND SECONDARY GLAUCOMA RELIEVED BY EXTRACTION OF LENSES

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The term spherophakia designates an unusual shape of the lens approaching a sphere. It is the result of abnormal laxity of the fibers of the suspensory ligament, allowing the natural elasticity of the lens full play. As a result, the lens is much thicker from front to back than is the case normally, and the observer gets the impression that it is smaller than normal; when the pupil is dilated he can see all around the lens except perhaps on one side. Because of this abnormal laxity of the suspensory-ligament fibers, the lens is also liable to luxation. Dislocated lenses have been divided by Elschnig into three groups, according to the frequency of their occurrence: (1) traumatic, (2) secondary to ocular disease, (3) congenital. One is inclined nowadays to doubt his figures and to regard the congenital group as most common. The condition in the congenital group is almost always bilateral, and recent reports of arachnodactyly cases lead us to believe that all congenital dislocations are a part of this syndrome, which may be complete or incomplete. The latter type may show only the congenital dislocation of the lenses or only the skeletal changes. Quite a number of arachnodactyly cases have been found at the Brooklyn Eye and Ear Hospital and reported by Dr. Ralph I. Lloyd. He has pointed out that a mother with only the bony changes may have children with typical complete arachnodactylia. Also, a mother with only congenital dislocation of the lenses may have offspring with the complete syndrome. In nearly all of the cases of bilateral dislocation of the lenses at the hospital, parents or grandparents were found with typical arachnodactylia. The only difference, apparently, between dislocation of the lens and spherophakia is that the suspensory-ligament fibers in the latter condition are lax and loose all around, while in the first type they are elongated or ruptured only on one side. It is reasonable to expect the spherophakia cases to be more liable to complete dislocation of the lens into the anterior chamber and from the literature this seems to be the case. In the cases reported with complete dislocation, an aggravation of the symptoms of glaucoma has been seen usually after the use of miotics. These have been tried both to reduce tension and also to fix the lens to facilitate extraction. The symptoms of glaucoma have been uniformly relieved by dilating the pupil, and the lens usually comes promptly to the surface and is easily extracted. Attempts at needling have been reported as failures.

These practical points are all found in the literature but have been confirmed by experience with the two eyes of a seven-year-old boy who was brought to my office by his father because of poor vision, in June, 1935. He could count fingers at five feet with either eye. The irises were tremulous and there was no fundus reflex. With the pupils dilated, the lenses seemed

very small and far back. There was a slight dislocation inward and somewhat upward. The fibers of the zonule could be seen below and these were dotted with pigment. The boy seemed duller than the normal child and it was not easy to examine him with the slitlamp. There were many fine dots scattered throughout the cortexes of both lenses and one could not get a view of the fundus. Retinoscopy indicated —14.00 diopters, O.U. Vision with correction was 10/200 for each eye. He was not seen again until January, 1936, when his father brought him again to the office because of the peculiar appearance of the right eye. There was marked ciliary injection of this eye, the pupil widely dilated and fixed, and the lens totally dislocated forward, with the lower pole in front of the iris and the upper pole tipped slightly backward. The peculiar spherical contour of the lens was now more plainly evident. Vision was reduced to light perception. In the hospital it was possible under a strong beam of light to cause the iris to contract violently and force the lens backward, but it returned to the original position within a few minutes. It was suggested that a miotic be instilled in the eye and the boy laid prone, i.e., face down. By this maneuver, it was hoped that the iris would keep the lens in the anterior chamber and facilitate its removal. It is known that when miotics are used in this type of case, an increase in tension can be expected because the iris hugs the lens and thus prevents the flow of fluid from the posterior to the anterior chamber. Mydriatics used in these cases promptly reduce the tension and the name "Glaucoma inversum" has been given to this type of ocular hypertension. In this case, the tension, which had been normal previously, rose to 45 mm. Hg (Schiötz) in about an hour after the pilocarpine was instilled and the patient complained of considerable pain. A few drops of 1-percent atropine reduced the tension to normal within a short time.

On the following day, the lens was removed without difficulty. Except that a slight iris prolapse required correction, the recovery was uneventful. The left eye showed progressive increase in myopia to —18.00 diopters. About six months after the extraction of the right lens, the child was brought to the office again. This time the left lens had become totally dislocated into the anterior chamber. The eye was markedly congested, the tension was elevated, and there was considerable pain. Atropine sulphate, 1-percent solution, was immediately instilled and both tension and pain soon abated. The lens was extracted on the following day without difficulty and recovery was again uneventful. Both fundi can be seen easily now and both are normal. The weight of the left lens was 157 mgm. Its measurements laterally and vertically were each 7 mm. The antero-posterior diameter was 6 mm. A trace of the flattening regularly found on the anterior surface was present. It is worth noting that there was no tendency of the lens to drop back into the vitreous, and the abnormally light weight of the lens may explain why both lenses came so readily to the incision and why the removal of this one was so easy.

Fig. 1 (Jacobs). Spherophakia. Left eye of seven-year-old boy. The roundness of the lens is evident.

Unfortunately, we did not measure the right lens but both seemed clear and transparent to the naked eye, although both were so cloudy to the slitlamp and vision was so poor. The refraction now, after sufficient time has elapsed for all irritation to disappear and the postoperative adjustments to go on to completion, is as follows: O.D. + 10.00 D. sph. ⊂⊃ + 2.00 D. cyl. axis. 170°, with 20/30 vision, and O.S. + 12.00 D. sph., with 20/30 vision. The high degree of myopia was entirely due to the abnormal curvature of the lens and it increased as the lens came forward. The total change in the refraction of the left eye amounted to 30 diopters as compared to the usual 10 or 12 diopters.

The tendency among adults for the lens to drop back into the vitreous is so common that an explanation of the rise of the lenses to the surface in this case, and also in those reported, would quite naturally be sought. This is probably due to the weight and consequently lighter gravity of the lens. According to Gnad, the lenses of a five-year-old child weighed .1587 and .1585 gm. and those of a seven-year-old, .1701 and .1703 gm. The diameters for the same ages were, respectively, 7 and 8 mm. for the equatorial and 3.25 and 3 mm. for the sagittal. The abnormal roundness of the lens of my patient is evident if we compare the antero-posterior diameter of his left lens, 6 mm., with that of Gnad's normal eyes of five and seven year-old children. The weight of the normal adult lens has been given by Sappy as 218 mgm., by Grunert as 221 mgm., and by Vierordt as 280-290 mgm. The great difference in the spherophakic lens and that of normal children, one to 12 years of age, is in the antero-posterior diameter, which varies from 2.46 mm. to 3.6 mm., according to Dub. This is to be compared with the 6-mm. measurement in this case. Quite naturally the adult lens is heavier than that of a child, but with the marked increase in antero-posterior diameter with relatively normal lateral and vertical dimensions, the specific gravity is very low. In comparison with the lens of an adult as it is extracted in capsule, the lenses of this child seemed very much thicker from front to back and required considerable coaxing to get them through the opening made by a liberal limbal incision.

I am indebted to Dr. Ralph I. Lloyd for his courtesy in placing a résumé of the literature on the subject at my disposal.

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NOTES, CASES, INSTRUMENTS

OPHTHALMOLOGICAL INDICATIONS OF DISEASE

A STUDY OF ANCIENT SKULLS IN THE NATIONAL MUSEUM

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In the Division of Physical Anthropology of the U. S. National Museum, headed by Dr. Ales Hrdlicka, are to be found a series of skulls that should be of much interest to ophthalmologists. Most of these skulls are of pre-Columbian Indians of Peru; two date from the XII dynasty of Egypt (2000 B.C.). The most interesting specimens in this group are from children under five years of age.

These skulls show a symmetrical disease process confined to the frontal, parietal, and occipital bones, some of them having marked manifestations in the roof of the orbits. Dr. Hrdlicka has called the lesions "symmetric osteoporosis." The osteoporosis remains largely in those individuals who evidently recovered.

In the roof of the orbits there was a hyperplastic sponge or corallike manifestation in the earlier stages. This was present in both orbits.

Quoting from Smithsonian Miscellaneous Collections, Vol. 61, No. 18, "Anthropological work in Peru in 1913 with notes on the pathology of the ancient Peruvians" by Dr. Ales Hrdlicka: "The process began, as can well be seen from the numerous specimens, in the roof of the orbits, or on each side of the frontal squama, between the frontal tuberosity and the coronal suture. In the orbits it began by an increase of vascularity, followed by deposition of porous tissue, which in extreme cases came to look exactly like a growth of coral. On the frontal the first changes were more like those of localized periostitis, but eventually led also to more or less surface osteoporosis. . . . If recovery took place, there was some thickening of the affected parts of the skull, disappearance of all overgrowth, and a persistence of more or less of a sievelike condition of the altered surfaces."

"The condition here briefly described was not rachitic, for rachitis did not exist in the pre-Columbian Indian. It cannot be assumed to have been syphilitic, for in no case were there any manifestations present that would point to that disease, . . . nor was it part of a tuberculous affection, for the lesions differ greatly from those of this disease."

In a footnote Dr. Hrdlicka says "In 1909 the writer brought two infant skulls with corallike osteoporotic development in the roof of each orbit from a XII dynasty cemetery in Egypt. . . ."

As far as the orbital lesions were concerned, I found one of these Egyptian skulls the most interesting. Dr. Hrdlicka stated that this skull was from a child about four years of age. The corallike development entirely covered the roof of the orbits, extending to the edge of the orbital ridges and was probably 4 mm. thick. It must have caused some displacement of the eyeballs. Among the most frequent sites of the early lesions was the top of the head, above the insertion of the muscles. It was here that the signs of increased vascularity in the early stages was most evident. The vascular changes are indicated by symmetrically placed areas in which the beds of new-formed blood vessels are quite evident. These channels of new-formed vessels radiate

from a central point and cause one to think of the spokes of a wheel or a rosette. Dr. Hrdlicka states that in Peru the skulls showing these peculiar lesions were found by him only in burial places along the coast. They were not found in the mountains.

The symmetrical development of these bone changes caused Dr. Hrdlicka to consider them as manifestations of some peculiar deficiency disease, which rarely still occurs among the Indians as well as the Eskimo.* I find no evidence that the orbital manifestations have ever been described clinically.

VISION IN PERNICIOUS ANEMIA

EDWARD JACKSON, M.D., Sc.D., F.A.C.S.
Denver

In 1882, in consultation with Dr. Isaac Massey, of West Chester, Pennsylvania, a patient was seen, a woman of about 30 years, who had been weak and anemic for some months and had developed obscure nervous symptoms that suggested the possibility of brain tumor. The writer was asked to test her vision and make an ophthalmoscopic examination. Vision was about 20/40 without opacities of the media or important error of refraction to explain the poor vision. The ophthalmoscope showed the pale fundus and the retinal-vessel changes of anemia. The optic discs were quite hazy, slightly red and swollen, but with no evidence of choking; no tortuous veins nor relative narrowing of the arteries.

The patient was seen several times in the next few weeks, showing no material changes in the eyegrounds, which were alike. The patient lived in the country and was confined to bed. Only the confrontation test was used to examine the visual fields. This was repeated and seemed to show that the peripheral boundaries of the fields were normal. There was no hemianopsia and no noticeable scotoma. It was concluded that there was no gross cerebral lesion.

As the case was watched it became evident from the blood count that it was a case of pernicious anemia, resembling the condition described by Addison in 1855, and brought to renewed notice by Stephen Mackenzie (Lancet, December 7-14, 1878). Mackenzie noted in addition to the appearances of the vessels numerous retinal hemorrhages, and in one case "optic neuritis"; but no impairment of vision or fields was noted, although his patient, a boy of 10, was under observation several months until death intervened.

Our patient grew worse and died a few months later of the anemia. The case was not reported, but was kept in mind in the expectation that another case of the kind might be encountered. But none has been seen by the writer, nor noticed in the literature, until within the past year. In the Lancet for November 21, 1936, under the heading of "Optic atrophy as the presenting sign in pernicious anemia," Prof. Henry Cohen of Liverpool has reported two closely related cases; and in the Lancet for November 28th, Dr. Charles R. Box, of London, reported another case as "Amaurosis in pernicious anemia."

The first case, reported by Dr. Cohen, was that of a man of 55 years, otherwise healthy, whose vision had been failing for a year, and was then R. 6/36, L. 6/60. His reflexes were normal. The optic discs were pale, and a slight contraction of the visual fields to a 2-mm. white object was observed. Six months later the patient returned showing deterioration of vision to 6/60 in both eyes. For two months there had been easy fatigue, and his blood count now revealed red blood cells reduced to

* Personal communication from Dr. Ales Hrdlicka.

1,730,000. He was put on treatment for pernicious anemia, and five months later had increased his red-blood-cell count to 4,300,000, hemoglobin 97 percent, and vision 6/12 in each eye.

The second case was that of a man of 46 years, otherwise healthy, who had noticed blurring of vision for eight months. Vision was R. 6/60, L. 6/60, with slight contraction of the visual fields. After one month's treatment for pernicious anemia his red-blood-cell count was 4,700,000, hemoglobin 94 percent, and his vision was R. 6/12, L. 6/9.

The patient of Dr. Box was a doctor, 67 years old, who had noticed tingling of the hands and feet, with stiffness of the knees. Vision with correcting glasses was 6/12. His red blood cells numbered 2,700,000, and the hemoglobin was 54 percent. After three months' treatment for pernicious anemia the red-blood-cell count was 5,000,000, and the patient was able to read the paper, "which he was quite unable to do on admission."

These three recent cases seem to have been examined by competent ophthalmologists. But an ophthalmologist of large experience would not be inclined to base a diagnosis of optic atrophy or amaurosis on these symptoms, especially when followed by recovery under treatment.

A more reasonable explanation of all these cases would seem to be: That the great impairment of general nutrition, characteristic of pernicious anemia, had, for the time, impaired the function of the macular region of the retina. It is known that this part of the retina is of recent development, from the standpoint of evolution, and develops late in the individual eye. In view of its recent development we must agree that it is particularly liable to damage from causes of impaired nutrition. Its behaviour in these cases reminds us of cases of toxic amblyopia from alcohol or tobacco. Whatever theory we hold of the nature of such amblyopia, it is important to know that it may be an early symptom of pernicious anemia and is quite amenable to the appropriate treatment.

Since writing the above, the writer has seen a woman of 57 years who, one year ago, had pernicious anemia. Under treatment, vision in the left eye was restored to normal. The right disc was pale and deeply cupped, probably as a congenital defect.

Republic Building.

SOCIETY PROCEEDINGS

ROYAL SOCIETY OF MEDICINE, LONDON

SECTION OF OPHTHALMOLOGY

January 8, 1937

MR. W. H. MCMULLEN, *president*

MELANOMA OF THE IRIS

MR. F. A. JULER presented a man, aged 70 years, who came for glasses last month, and Mr. Juler noticed an iris tumor. The patient had not noticed the discoloration of the iris. The exhibitor was anxious to know whether members considered the tumor to be malignant, and, if they did, what they would recommend as the right treatment. The tumor affected two thirds of the width of the iris stroma, and protruded forwards into the anterior chamber, especially below the pupillary margin. There was a slight pulling of the pupil downwards. He did not know how that could be explained if the tumor were malignant. There was slight ectropion of uveal pigment at the pupillary margin. The grayish-brown coloring of the tumor suggested something which was actively growing, rather than a congenital mole. He remembered a case some years ago, of apparently innocent melanoma of the iris, and this also protruded to some degree into the anterior chamber; 14 months later there was no change.

Discussion. Mr. Charles Goulden said he had seen a few cases of colored growth of the iris, and remembered the frequency with which they were in the lower part of the iris, though the last one he saw was in the upper part of the iris, and was very similar to the case which Mr. Juler had shown. A point of importance in diagnosing malignant disease was the deformity of the iris. If a case was merely one of mole of the iris, the shape of the iris was not found to be deformed, but it was deformed by malignant growth. In this case of Mr. Juler, as in the last case he saw, the root of the iris was free from growth. He successfully removed the tumor in his own case by iridectomy. Several years later, he saw the patient and found the eye in good condition, except, of course, that a large piece of iris was missing. He thought Mr. Juler would find iridectomy successful in the present case.

Mr. Leighton Davies (Cardiff) said he had seen two or three cases which were somewhat similar to this, but they were in people with dark irides. He had watched them for several years, and in each case there was an elevation of the tumor above the surface of the iris. He did not remember whether they caused distortion of the pupil. But they had not altered in three or four years. His view about the case now shown was that it was not malignant, or, if malignant, it was probably a melanotic sarcoma. He was surprised by the remark of Mr. Goulden, because his own experience had been that these tumors invariably produced secondary deposits in other parts within 12 months. So, if this was a case of melanotic sarcoma, he did not think one could hope to save the patient's life by removing a portion of the iris.

Mr. A. F. MacCallan said that in the last few years he had shown at the meetings of the Section two cases similar to that of Mr. Juler and in them the condition had remained the same for many years. In his opinion Mr. Juler's case was one of mole, not of malignant growth.

Mr. W. H. McMullen said the fact that the wife had not noticed it suggested that

the condition in the eye was not new; if it had been recent he thought that, even at their time of life, it would have been noticed. Also, he thought the arrangement of the uveal pigment here was against malignancy. He did not see why the pigment layer should grow over a growth in that way. His advice would be to wait and watch the case before thinking of operating, making, from time to time, estimates of its size.

Hemispherical formations in Bowman's membrane

Mr. Eugene Wolff and Mr. T. Keith Lyle presented a paper on this subject. The patient, they said, was a stevedore, aged 32 years, in whom idiopathic epilepsy had been diagnosed. He also had detached retina of the left eye, of traumatic origin, with secondary glaucoma. When 15 years of age he had sustained an injury to his left eye with a tennis ball, and since then his vision had been blurred. At 23 years of age the sight of the left eye became much worse, a black film appearing to spread over that eye from the inner margin, and within three years he had become quite blind in that eye. When 17 years old he began to suffer from dizzy spells, and at 21 years had attacks of petit mal, followed at a later date by grand mal. Sometimes he had as many as three or four attacks a day. His right eye had 6/6 vision, and the fundus was normal. In the left eye the tension was plus 2, the cornea was edematous, the lens slightly opaque, the optic disc cupped, the media were hazy, and there was an extensive detachment of retina. The blood pressure was 125/70; the cerebrospinal fluid apparently normal. The treatment, carried out last year, was excision of the left eye, with the insertion of a fat graft taken from the anterior abdominal wall into Tenon's capsule.

The structures in Bowman's membrane were found on routine pathological examination of the eye. They were more or less hemispherical, and fairly homogeneous in structure. In size they varied up to about 10 mu at their bases. Some 60 could be seen in each section. There were more of them towards the central than in the peripheral parts of the cornea, and they were nearest the epithelium. These structures were actually in, not on, Bowman's membrane, and that membrane was not pushed backwards, as was evidenced by its straight posterior border.

These hemispherical formations stained red with hematoxylin and eosin, orange-red or red with Van Gieson stain. That the structures did not consist of amyloid was shown by the fact that they did not give the characteristic stain with methyl violet or Congo red. Kuhne's stain for hyaline tissue stained them a deep blue, therefore it was probable they were of that nature.

While glaucoma probably played some part in their formation, there must be some other factor, as so many eyes which were removed because of increased tension did not contain these bodies. The authors thought their shape might be due to a distension of the canals for, or degeneration of, the nerves which perforated Bowman's membrane, so they stained the tissue by Bielschowsky's method.

It would seem that these hemispherical bodies were hyaline in nature, were probably produced by degenerative products of the corneal epithelial cells, or a degeneration of the perforating nerves, and while it was probable that glaucoma played some part in their formation, their exact cause remained unknown.

Experimental staining of the retina during life

Mr. Arnold Sorsby, Mr. A. Alkeles, Dr. G. W. Goodhart, and Mr. I. B.

MORRIS presented a paper on this subject. Their problem in this investigation was to determine whether it would be possible to stain the retina clinically during life. Could they make the translucent retina visible ophthalmoscopically by staining in life? In optic atrophy the fundus reflex is normal, but it is known, from histological preparations, that the retina is extensively degenerated. Vital staining has been applied to other tissues, both for histological purposes and as a therapeutic measure. An example of the latter is the use of various vital dyes in leprosy. The difficulties in staining the retina are bound up with those which have been encountered in staining the nervous system as a whole. There appears to be a barrier between blood and the nervous tissue, a holding back of many substances circulating in the blood, so preventing them from reaching the cerebrospinal fluid and the brain. The mechanism of this barrier has been the subject of much dispute, but there can no longer be any doubt as to its existence; the mere difference in the composition of blood and cerebrospinal fluid is enough evidence as to that fact. The blood-brain barrier prevents entry into the brain of not only various colloids found existing in the blood stream, but also toxins, and such medication as arsenic. In this way the blood-brain barrier acts as a mechanism for the protection of the brain. The same mechanism, however, is a detriment in some conditions, as, for instance, in cerebrospinal syphilis, as it effectively prevents the therapeutic agent from coming into contact with the brain. The existence of this blood-brain barrier had been studied through observing the action of various dyes injected intravenously. Since the classical experiments which were carried out by Goldmann in 1913, it has been the prevailing view that the choroidal plexus plays a dominant part, because trypan blue, the dye used in these experiments, was found mobilized in the plexus, none of it being found in the brain tissue itself. The existence of the blood-brain barrier has been regarded as an insurmountable difficulty in vital staining of the brain. The same mechanism which prevents vital staining of the brain is, presumably, effective in preventing staining of the retina. Such work as has been done on vital staining of the eye has dealt largely with demonstrating the mechanism of formation of the aqueous by the ciliary body.

Yet recent work has shown that the blood-brain barrier referred to is not an absolute barrier; it has been proved that it is effective for acid dyes only, as basic dyes have been observed to stain the brain. Experiments carried out with acid dyes failed to produce any staining of the retina. The injection of these basic dyes gave results difficult to interpret, for all the basic dyes are highly toxic, and any staining that was obtained might well have been a supravital phenomenon, and so it held out little promise for clinical application.

Further work consisted of a search for a nontoxic dye which would pass the blood-brain barrier and produce the desired staining of the retina. Light green S.F. was found to answer the purpose, as it was nontoxic to the rabbit and caused a transient staining of the fundus when injected intravenously. Staining of any duration clearly affecting the retina could not be obtained in the healthy rabbit. Degeneration of the rabbit's retina was then experimentally produced by the intravenous injection of septojol, an iodine preparation. When such rabbits were subjected to the injection of light green, the same transient staining as in normal rabbits was obtained at the time of the injection. Half an hour later, in these rabbits, the fundus showed an intensive

green coloration, which was of irregular distribution. This, however, could not be obtained in the normal rabbit, and this failure to do so was, presumably, because the normal rabbit's retina converted the dye into a leuco-base oxidation, the damaged retina doing so to a much more limited extent. Further investigations showed that the same results could be obtained by intramuscular injection of the dye. The histological result showed the dye in the retina.

In presenting this preliminary report of the work, the workers had in mind the possible fallacies. The investigation is being continued for the purpose of ascertaining to what extent vital staining could help to elucidate problems connected with the metabolism of the normal retina and showed that the same results could be applied clinically to demonstrate atrophic and degenerative processes.

(Reported by H. Dickinson.)

MEMPHIS SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

January 11, 1937

Dr. W. D. Stinson, *presiding*

Vernal conjunctivitis

Dr. E. C. Ellett presented the patient with granular conjunctivitis whom he showed two years ago. The left eye grew worse in spite of treatment. Various astringents, cautery, diathermy, and cutting of the granulations did not help. The cornea was slightly involved at times and now shows a faint sort of pannus in the upper half. In July, the tarsal cartilage in this eye was removed. Examination of the tissue was made at the Army Medical Museum and a diagnosis given of vernal conjunctivitis.

The right eye has become worse. There are many large funguslike elevations on the inner side of the upper lid. No treatment has been administered to this lid, and the cornea is not involved.

Two strange tumors of the eyelid

Dr. A. C. Lewis presented Mr. I. M. N., aged 40 years. He gave a history of chronic redness and swelling of the left upper eyelid. This is caused by a stye which breaks at frequent intervals but never disappears. Upon opening the stye, the knife struck a bonelike substance which resembles a coral bead about 2 mm. in diameter. This is the first time he had seen a stone in the follicles of the cilia.

Dr. A. C. Lewis reported the case of Mr. S. P., aged 24 years, who had on the upper lid of the left eye a large tumor mass that had been present all his life but that had been getting much larger for several years. The eye was blind from leucoma and pupillary occlusion caused by a blow to this eye a few years previously. The growth was present before the accident occurred. The eye was practically closed by the weight and position of the tumor. It was beneath the skin and orbicularis, just under the rim of the orbit, and extended to the outer angle of the orbit. A horizontal incision parallel to the orbital rim was made and the tumor exposed and removed intact. It was the size and shape of an adult human eyeball. Apparently it was a mucocele.

Alcohol amblyopia

Dr. R. O. Rychener presented P. A. M., aged 46 years, who for a year had imbibed a pint of whiskey daily and smoked moderately. Several weeks before consultation on January 21, 1937, he had complained of failing vision. Visual acuity with myopic correction was 6/12 and J 10 in each eye; the fundus condition was normal, but there was a relative central scotoma in each visual field. His physician made a diagnosis of chronic alco-

holism with early cirrhosis, and the alcohol and tobacco were both withdrawn, while sodium nitrite was given intravenously. This was later discontinued because of the difficulty of administration due to the small caliber of the cubital veins.

Despite treatment, visual acuity diminished to 6/60 and 6/15. At this point the blood sugar was found to be elevated to 166 mg. and insulin therapy was instituted. Five days later vision had returned to 6/7.5 and J 1, and the patient was mentally alert and active and felt like a changed individual. Recent experiments have shown that alcohol disappears from the tissues very rapidly upon the administration of insulin and it is wondered whether any such direct effort could have played any part here.

Paresis of superior-rectus muscle and spasm of inferior-oblique muscle with headtilting

Dr. R. O. Rychener presented C. P., aged eight years, who was having some difficulty in his school work. He was left-handed and a mirror writer and had always held his head tilted forward and to the right. There was anisometropia with a high astigmatic error in the right eye, but the vision with correction was 6/6 in each eye with a left hyperphoria of four centrads in the primary position. The right eye lagged slightly on upward rotation and when the eyes were turned to the right and up there was a sharp upshoot of the left eye. Glasses for study were prescribed and tenotomy of the left inferior oblique advised.

Magnet extraction of intraocular foreign body

Dr. R. O. Rychener presented R. C., colored, aged 34 years, who was seen 24 hours after a metallic foreign body had pierced the left eye while he was pounding a tractor bar. A foreign body 2 x 4 x 8 mm. was located in the mesial quadrant, 17 mm. behind the cornea. It had entered the eye under the caruncle through the belly of the internal-rectus muscle. Blood in the vitreous and detachment of the mesial portion of the retina obscured its position, although the nerve head could be seen. Difficulty was encountered in finding the scleral wound of entrance because of the presence of the muscle, and because the eye was apparently lost, a scleral incision was made parallel to the lower border of the muscle and the foreign body extracted with the Lancaster magnet. One week later the retina had become perfectly reattached, the original wound of entrance and the operative incision were recognizable as two chorioretinal holes, and the vision with correction was 6/6, which has been maintained to date.

Retrobulbar neuritis

Dr. J. Wesley McKinney presented W. T. G., aged 60 years, whose left eye was blind from an injury and who first sought treatment on November 28, 1936. His complaint was that the vision of the right eye had been blurred for three weeks, but that it had been very poor for two days. There was no alcohol, drug, nor tobacco history. Vision was right eye 5/60 and J 16 uncorrected by glasses, and left eye no light perception. The external examination was negative. There were weblike opacities in the vitreous. The disc showed a very slight pallor temporally. The arteries were fine, with moderate sclerosis and angiospasm. The blood pressure was 170/125. There were scattered small hard exudates at the posterior pole and one faint flame-shaped hemorrhage three disc diameters directly below the disc. The macula appeared to be normal. The peripheral fields were normal. The central fields showed a normal blind spot

and a four-degree absolute central scotoma for white and a seven-degree scotoma for red.

The impression was of a retrobulbar neuritis on an arteriosclerotic and angiospastic basis. The patient was given one gram of sodium nitrite intravenously and sent for general and nose and throat examinations. These were reported negative except for the hypertension and a slightly suspicious right antrum. The next day, November 29, 1936, the vision was 6/9, corrected to 6/4.5 and J 1. There was definitely less spasm of the retinal arteries and the scotoma had disappeared completely. Today, January 11th, the vision is 6/4.5 and J 1.

Oxycephaly

Dr. M. B. Seligstein presented B. W., a 40-year-old colored man, who was first examined on November 23, 1936. Vision first began to fail in 1928. History revealed that he had had eight injections in nine days, which could not have been of salvarsan. Vision in the right eye was 20/65, in the left eye, light perception and ability to see hand movements. A primary optic atrophy of both discs was present and periarteritis of the retinal vessels. The Kahn test for blood and spinal fluid was negative. The contour of the skull was definitely that of oxycephaly with definite digitation and thinning of all skull bones, complete obliteration of all suture lines, and very large oval-shaped sella turcica but no positive signs of erosions of the clinoid processes.

Scurvy

Dr. C. D. Pittman by invitation presented A. W., a girl aged 10 months, who on March 20, 1936, was admitted to the clinic with the complaint of swelling eyes, soreness of mouth, and general soreness of bones and joints on pressure. The patient was a normal full-term baby, bottle fed, had received no cod-liver oil nor orange juice and had had no childhood diseases. The present illness was first noted shortly after January 6th when the child fell and hurt her mouth. The gums became sore and bled on least pressure. About March 1st all joints and muscles of the body became sore, and the child cried at least pressure. Ten days ago the right eye became swollen, which was followed in a few days by swelling of the left eye. There was an ecchymosis around the orbit of the right eye and a limitation of motion of the right eye. The pupils were active and equal, the fundi normal. The gums of the upper portion of the mouth were gangrenous and foul smelling; they bled easily. There was a moderate edema of the lower extremities.

X-ray films showed a periosteal hyperplasia of the long bones with fuzziness and flaring of the ends of the diaphysis; also some increased density of the cortical portion of the long bones.

Blood count showed 3,900,000 red blood cells; 9,500 white blood cells; polymorphonuclear leucocytes 40, lymphocytes 56, monocytes 4, hemoglobin 65 percent, platelets 1,621,500. Smears were repeatedly negative for gonococci. The diagnosis was scurvy with retrobulbar hemorrhage.

The child was first given blood intramuscularly and intravenously; then orange juice 2 oz. daily; 3d, cereal and vegetables; 4th, cod-liver oil 0.5 dram, three times a day; 5th, iron and ammonium citrate grs. 15, four times a day.

Slow improvement followed under antiscorbutic treatment. The child became less fretful and the swelling of the eyes subsided. She was discharged from the hospital April 13, 1936, with weight gain of one pound, but little change in the blood picture.

J. Wesley McKinney,
Secretary.

COLLEGE OF PHYSICIANS OF PHILADELPHIA

SECTION ON OPHTHALMOLOGY

January 21, 1937

DR. CHARLES R. HEED, *chairman*

EXHIBITION OF A CASE OF SPONTANEOUS REATTACHMENT OF THE RETINA

DR. WILLIAM ZENTMAYER said that his patient was being presented in connection with Dr. Buchanan's case because of a complete spontaneous replacement of the retina following a detachment probably exudative in origin.

The vision in the right eye became distorted in April, 1930. The first examination was made in September of that year when it was found that vision equalled 6/15 and the upper part of the field of vision was lost. There was a separation of the retina which began at about the horizontal meridian of the fundus and extended forward to the ora serrata. There was already a marked retinitis striata, a white band demarcating the limit of the separation. The anterior part of the retina was thrown into small folds, and on the temporal side, well forward, there was an area of choroiditis about which there were a half dozen or more gray almost globular bodies, each about three times the diameter of the central artery of the retina, similar in appearance to the lesions seen in sympathetic ophthalmia. There were a few striae in the posterior cortex.

By the latter part of October the bodies had disappeared. It was not until August, 1932, that it was noted that the retina was back entirely in place and the field again full. The picture is now one of sequelae of the retinochoroiditis with unusual development of retinitis striata. The vision is 6/9. The patient was seen in consultation by Dr. deSchweinitz, who gave a more favorable prognosis.

The left eye of this patient presents a striking example of traumatic proliferative retinochoroiditis. When the patient was five-and-one-half years old this eye had been injured by a "BB" shot from an air rifle. There was a rupture of the sclera on the nasal side on the ciliary region. Dr. Zentmayer had closed the wound with a few sutures and the eye recovered with no external evidence of the injury, but unfortunately without any vision. The eye is now widely divergent.

A CASE OF DETACHMENT OF THE RETINA WITH SPONTANEOUS REATTACHMENT

DR. MARY BUCHANAN said that this was so unique a case that she hardly knew what to call it. Miss C. B. R. came to the Woman's College Hospital Eye Clinic in March, 1920, some five weeks after her discharge from the Mount Sinai Hospital convalescent from an attack of influenza-pneumonia. She was practically blind. Her right eye had a detached retina and her left eye a cataract. After six weeks' treatment with Mulford's Serobacterin Influenza Mixed her vision improved to O.D. 5/30 and O.S. 5/60.

On August 9, 1920, the cataract was extracted from the left eye and with —2.00 D.sph. ⊂⊃ —2.50 D.cyl. ax. 85° vision was 5/15. In 1925, the right cataract was extracted; with a —8.00 D.cyl. ax. 100°, vision was 5/22. In 1926, following extraction of several teeth without gas, the right eye suffered an intraocular hemorrhage and had to be enucleated.

In the meantime the vision of the left eye became rapidly reduced. In 1933 Miss R. received a blind pension. Last spring she reported that there was something hanging over the central sight and the vision was gone. With the ophthalmoscope a white wall was seen but no details could be obtained. Later the large posterior staphyloma could be seen but neither choroidal nor retinal vessels were visible. She

had no peripheral vision. In August, 1936, she bumped into a friend's elbow striking her left eye. She said it felt like compressing a rubber ball. She later found that she could see better toward the temporal side, even being able to distinguish men and women walking below her third-story window. Her visual field, taken October 21, 1936, extends 60 degrees below the horizontal line and 15 degrees above and 20 degrees to the nasal side. Her vision is 1.5/60. On January 18, 1937, the field was somewhat more contracted, but with the ophthalmoscope large vessels, a large staphyloma, and two large patches of sclera could be seen at the nasal side.

A case of uveoparotitis in a 32-year-old male negro

Dr. A. G. Fewell and Dr. W. Luther Kauffman said that the condition is of about eight weeks' duration and has the following features: bilateral markedly enlarged and indurated parotid glands, right facial paralysis, and some of the features of uveitis in either eye. The chest X-ray film revealed thickening of the hilum shadows. The blood count revealed a leukopenia and eosinophilia. This case will be reported in full from Pennsylvania Hospital, service of Dr. W. Estell Lee through whose courtesy the patient is presented.

Illumination

Dr. Alfred Cowan gave a short and very general discussion on this subject. It was his opinion that ophthalmologists should be familiar with the problem of artificial lighting and in agreement with illuminating engineers in their endeavors to secure higher intensities and proper arrangements of lighting fixtures.

Text cards should be illuminated by about 100 foot-candles with adequately lighted surroundings. Wide variations in the intensities around this range will cause relatively small changes in the visual acuity. Also, with this amount of illumination there will be less fatigue for the patient in those instances in which considerable time is required for subjective refractions.

He said that Dr. Crampton is correct in that glare will cause fatigue; but there should be no glare in the illumination of test cards if the surroundings are properly lighted. It is very important that the room in which a highly illuminated test card is used should be diffusedly illuminated in the proper proportion in order to eliminate glare. Dr. Crampton stated that in these high ranges of illumination the card itself may become a source of glare irrespective of the surroundings, and as Dr. Cowan suggested, contrasting surroundings would add to the fatigue.

Experimental and clinical studies of cataract

Dr. I. S. Tassman presented, first, a brief review of the earlier literature, beginning with a publication by Moerner, who in 1894 described the chemical analysis of the crystalline lens and its fractions, which was followed by later investigations showing the chemical changes that take place in the crystalline lens during the development of senile cataract. As nearly as possible, his investigations were grouped as follows: 1. Experimental cataracts, such as those produced by feeding animals with either naphthalene, lactose, or galactose. 2. Cataracts as the result of either light rays or heat. 3. Cataracts of so-called endocrine origin. 4. Vitamin deficiency, particularly vitamin C, and its relationship to the development of cataract. 5. Immunologic studies, with reference to cataract.

Discussion. Dr. C. A. Clapp said that Dr. Tassman has mentioned Professor Vogt's work along the line of glassblowers' or radiation cataract. We are

aware there has been much controversy as to whether the opacities which develop are the result of heat or of the infrared rays. He had seen Dr. Vogt give rabbits an irradiation with the infrared rays at 9 a.m. and at 2 p.m. on the same day the lenses showed a general clouding.

Dr. Clapp had had a series of rats on the vitamin-G deficiency diet of Langston and Day but his rats did not develop cataract so frequently as theirs did. In every case in the rats which did develop lenticular opacities, he believes that one could detect damage in the capsular epithelium. He was inclined to believe that this damage by altering the nutrition to the lens fibers causes the opacities. The series of rats placed on the lactose and galactose diets was also disappointing, since all the rats died before opacities developed.

While Dr. Tassman did not mention the dinitrophenol cataracts, he believes this type is also caused by damage to the capsular epithelium or to the epithelium of the ciliary processes, either one of which may disturb the nutrition of the lens. Dally believes that the so-called dinitrophenol cataracts are not due to dinitrophenol but to dinitronaphthol, which may occur as an impurity, since no cases of this character have occurred in France but all have originated in the United States. Animal experimentation seems to be without results, since so far his animals have failed to develop any opacities of the lenses.

*p*H AND BUFFERS IN OPHTHALMOLOGY

DR. J. B. FELDMAN said that distilled waters vary in *p*H and, therefore, the same medications made with different distilled waters were found to vary.

The *p*H of the tears in either health or disease in the same individuals may be different from time to time. Neither is the *p*H of a person's two eyes always the same. The average range of *p*H of tears is between 7.0 and 7.5. Extraocular diseases do not give typical changes in pH of tears. The paper will be published in the Archives of Ophthalmology.

A. G. Fewell,
Clerk.

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WHO SHALL REFRACT?

The ideal method for determining the refraction of the eyes would be to have each person needing such tests examined by some one thoroughly versed in medicine and well trained in the principles of refraction. The examiner should have no financial interest in the result of the examination. He should not profit either directly or indirectly from the sale of glasses that he prescribes; for it is not within human nature to be unprejudiced in judgment as to the need of glasses if the sole or even the major part of his financial remuneration, the bread and butter for himself and family, depends on the sale of the glasses that he orders.

That a medical training is of real importance in this procedure cannot be doubted when one considers the great number of diseases of the eyes, the close association of health and eyestrain, and the many ocular conditions that indicate serious systemic disturbances. Possible pathology should be sought for in any thorough ocular examination, and to do less than to make a complete study of the eyes of a patient who submits himself for refraction because of poor vision, or ocular pain, or because he desires a general ophthalmic investigation, is certainly to be neglectful of the best interests of the patient. It is true that patients frequently state that all they want is a test for glasses, for many labor under the delusion that poor vision is always due to errors of refraction and is correctable by lenses; which evidence of ignorance is a challenge to the ophthalmologist to point out the mistake in this concept.

It would seem that there were little room for argument with the foregoing, and it would be ideal if such service could be rendered to all; but the situation demands practical, not theoretical, handling. Considering the problem from this angle, what appears to be the best solution?

There are approximately 10,000 ophthalmologists and 20,000 optometrists who perform the bulk of the refraction in our country. Unfortunately, many members of each group are imperfectly trained. Ophthalmologists usually have sufficient medical background, but many of them have not had a desirable amount of special training in optics and refraction. Most optometrists lack medical knowledge, and many of them are not well trained in testing refraction and its related subjects.

It is not feasible in the immediate future for all who examine eyes to be fully educated in medicine and the principles of refraction, since this would necessitate there being at least three times as many ophthalmologists as now.

Let us, for argument's sake, entertain the fanciful suppositions that any such number of physicians could be induced to enter the ophthalmic field and to obtain the necessary special training, and that those without such training were not permitted to prescribe glasses. What would be the inevitable result? There would be little increase in the total amount of pathological, medical, or surgical ophthalmic material; for most diseased eyes ultimately reach the ophthalmologist, although often after long delay caused by nonrecognition during which time irreparable damage often occurs. Thus these elements in the physician's practice would be greatly reduced; the surgical to so small an amount that it would be impossible for more than a few men in each large community to perform enough operations either to acquire or to retain the necessary skill. This certain change in the character of the practice would offer the physician less inducement to enter the specialty and militate further against the probable provision of this increase in the number of ophthalmologists.

From these facts we may conclude that at present there is no possibility whereby the ophthalmologist may perform all of the needed tests of refraction. Whatever his original training, each refractionist should endeavor to improve his particular deficiencies, especially should learn to perform his refractive tests better, and the optometrist should learn more medicine, so that he can recognize with more certainty those cases needing medical attention.

There seems to be no way of eliminating the danger of giving a prejudiced decision when there is a financial interest in the judgment. This will always handicap the development of optometry, especially, and will similarly influence the opinion of those ophthalmologists who now dispense their own optical material and fail to differentiate for the patient the cost of the lenses and the fee for the examination, or who directly or indirectly receive remuneration from the sale of glasses. Charging a fee for the refractive test by the optometrist would not help the situation materially, because there would still remain the incentive to make a sale for the additional profit.

The most important point is that the public should be educated as to the difference between ophthalmologists and optometrists so that they may choose which type of ophthalmic examination they prefer, understanding just what they may expect from each. It is difficult to give this information clearly to the public because of the similarity of nomenclature, the use of the term "doctor" by the optometrist, and frequently his desire to confuse the public regarding his medical qualification.

This vexed question has no immediate

and permanent answer, but that is not necessary. Time will gradually answer it. Nothing will be gained by recriminations but much harm may be done, for such contests end in undermining the faith of the people. The ophthalmologist would indeed welcome successful attempts by the better elements in optometry in curbing extravagant and false advertising, but there are probably activities of ophthalmologists equally galling to optometrists.

There are many encouraging signs that continually better service will be evolved for the patient: ophthalmologists are stressing postgraduate teaching and standardizing it, are establishing better facilities for giving suitable training, and are increasingly accepting certification by the American Board of Ophthalmology as a stamp of excellence. Ultimately it may be that only the qualified man will be permitted to practice this specialty. Lay refractionists have raised the requirements for licensure throughout the United States and are constantly demanding better training and higher standards. The sum total of all this is reassuring.

Lawrence T. Post.

WHAT ARE "CURES" OF RETINAL DETACHMENT?

A friend, who but for his modesty might as well have written this editorial comment, complains of an excessive looseness in the use of the term "cure" as applied to the results of operations for retinal detachment.

He remarks that many surgeons have taken to speaking of a cure when they mean a reattachment, whereas from the patient's point of view such an outcome is often far from being a cure. It must be remembered that patients and their friends do not altogether favor the conception of a successful major surgical undertaking as one in which "the operation was successful but the patient died"; or, by the same token, one in which the operation was technically successful in its execution but the patient failed to recover his lost sight.

Reattachment of a detached retina may be a cause for surgical self-congratulation; but to the patient who has abundantly sacrificed of his time and money without the expected visual result it may appear indistinguishable from failure.

Thus, for practical purposes, our friend may be right in the suggestion that "to put it mildly, some of the men who are doing retinal-detachment surgery are consciously or unconsciously stretching the truth in their statistics."

The claim referred to in the following further note by our ophthalmic friend may be based upon a perfectly honest confusion of terminology, yet the criticism offers food for thought and a warning in the direction of restraint from misguided enthusiasm: "Two colleagues of mine have told me recently that they saw a letter signed by a man in the United States who is doing a good deal of retinal-detachment surgery, in which he made the statement that by the more recent methods he was curing ninety percent of his cases—there being no qualifying statement as to what was meant by 'cure'. The same persons who saw that letter have seen several cases that have been operated upon by the individual who signed the letter, and the cases were almost total failures."

Publication here of these frank murmurings may be justified by the general wholesomeness of Bobbie Burn's couplet

"O wad some power the giftie gie us
To see oursel's as ithers see us."

It is true that, although with many brilliant successes to its credit, the surgery of retinal detachment is still to some degree in the experimental stage. One of the frankest discussions of technique and

prognosis, of success and failure, is that contributed by Gradle in the issue of this Journal for October last. Gradle there points out that duration and area of detachment, although often regarded as setting bounds to possible success, do not always do so.

Thus, it is necessary to remember that in many cases detachment has probably existed much longer than the patient realizes; yet now and then a case whose known duration is a year or more responds to operation with recovery of industrially valuable visual acuity; to say nothing of such eyes as one mentioned by Gradle, in which the retina had been detached for three years and became reattached spontaneously during a long period of bed rest. Very wide extent of detachment, again, has commonly been regarded as precluding success from operation; yet there are records of cases in which the retina has become reattached in spite of a funnel-shaped detachment.

But the enthusiast and the optimist may also remember that, many months after an apparently brilliant anatomic and visual result, the eye may go down to ruin with a hopeless funnel-shaped detachment and secondary cataract.

The greatest surgeons are often the most modest as to their operative results. Yet the greatest of surgeons sometimes shows an undue bias toward excluding from his statistics cases which he decides to regard as having from the beginning constituted bad risks. Moreover, the surgeon who would use proper caution in reading or publishing a formal paper may not always display sufficient restraint and discretion in correspondence with surgical colleagues or prospective patients. It must not be forgotten also that most of the patients who have once developed retinal detachment continue to be subject to the risk of repeating their previous performance.

At least the prognosis must be guarded, and the claim of success must be based entirely upon the practical result to the patient. It is just as true in the surgery of retinal detachment as in any other line of surgery, that the patient who is given an exaggerated statement of what he may fairly expect from an operation is dishonestly dealt with. W. H. Crisp.

SUMMER OPHTHALMOLOGY

Sixty years ago the American Ophthalmological Society failed to hold a meeting, for the only time since it was founded, in 1864. That year it had ventured west to Niagara Falls, and only six members attended. Even the founder, Henry D. Noyes, then president, was absent. This venture into the western wilds made such an impression on the Society, that it did not again cross the Allegheny Mountains, until the year 1923, when it met at Colorado Springs with 51 members and 28 visitors in attendance. Since the American Medical Association will meet in San Francisco next June, the Council of the A.O.S. has decided to take a postcard vote, as to how many of its members wish to attend a meeting next year, to be held in California, near the time of the meeting of the A.M.A. The 1937 meeting of the A.O.S. was held near the familiar golf course at Hot Springs, Va. It was a good meeting, although many of the older and most famous of its members were missed.

In June, the A.M.A. met in Atlantic City, and the Section on Ophthalmology had its usual good program and attendance. In the recent meetings of the A.M.A., the Department of Scientific Exhibits has grown to be one of the most important features of the meeting, and at this session the exhibits were more numerous and impressive than ever be-

fore. Those from the Section on Ophthalmology again took a leading place.

This year the Western Ophthalmological Society held its fourth Annual Meeting in Denver. Heretofore its meetings have been confined to one day, but this year it filled two days. A joint evening meeting was held with the Section on Medical History of the Denver County Medical Society. The addresses were by John E. Weeks, of the Koch-Weeks bacillus, on "Early workers in bacteriology"; by Edward H. Cary, ex-president of the American Medical Association, who raised the question, "Did clinical specialization anticipate scientific medicine?"; by James J. Waring, who spoke of "Henry Sewall, physician and leader"; and by Melville Black and Robert Levy, who paid tribute to the character and achievements of William C. Bane. The Denver meeting showed that July is not a good time for this Society to meet; and next year, its meeting will be held in January, at Los Angeles.

Among summer meetings the Oxford Ophthalmological Congress must not be forgotten. This year America was represented by Arthur J. Bedell, of Albany, who showed his recently made photographs of the ocular fundus in natural colors. A feature of the Congress was a Symposium on myopia, opened by Bishop Harman and Arnold Sorsby. Harman emphasized the etiologic importance of near eye work. Sorsby argued the importance of heredity. Hormones and vitamins in ophthalmology, the subject of night blindness, plastic surgery of the lids, and other important subjects also claimed the attention of the Congress.

Among the summer gatherings devoted to ophthalmology must be numbered the various classes for graduate study. A new course of this kind was given at George Washington University, Washington, D.C. This started with about 150 present. The course at Rochester, N.Y., was given as in previous years. The class at Denver, Colorado, drawn from seventeen states, showed the steady improvement in training and experience of the men and women who seek the help such gatherings afford.

Nor should the work of the American Board for Ophthalmology be ignored. It was the first Board to hold such an examination for a certificate of training in a special branch of medicine. This was at Memphis, Tenn., in December, 1916. Now there are twelve such boards, under the supervision of the American Medical Association and the coöperating special societies. The Board for Ophthalmology has this year held examinations in Los Angeles, New York, Philadelphia, and Chicago.

Variety of activities is a condition of health. The participation in such meeting is a health need for all members of the profession. Edward Jackson.

BOOK NOTICES

THE OCULAR FUNDUS IN DIAGNOSIS AND TREATMENT. By Donald T. Atkinson, M.D. Clothbound, 259 pages with 106 illustrations including 58 colored plates. Lea & Febiger. Philadelphia, 1937. Price $10.00.

The book is divided into two sections, the first being the text, which is "as condensed as possible," and the second, a collection of 58 colored plates of the author's fundus drawings. In the preface the author states that the book differs from all others in English in that the illustrations are wholly the work of the author.

The text consists of chapters on the ophthalmoscope, the normal fundus, the ophthalmoscopic lesions of the various structures of the fundus, and a final chap-

ter on the fundus manifestations in special diseases. The text is illustrated by a number of composite drawings in black and white by the author. In view of the recent excellent work on arteriolar sclerosis and hypertensive retinitis, it is particularly disappointing that discussion of this condition is omitted. The discussion of optic-nerve inflammations is confusing in view of the lack of distinction between papillitis and papilledema. The value of the text would be increased by a better correlation of the ophthalmoscopic appearance with the histological findings and medical background.

The second section contains 58 colored plates of the more common fundus conditions which are the work of the author. Each plate is accompanied by a short clinical history. Since the plates tend to be diagrammatic and, as the author states, "lack the conventional technique of the academic painter," they fail to give as natural a picture as might be desired.

T. E. Sanders.

SENILE CATARACT. By W. A. Fisher. Third edition. Leatherette binding, 150 pages, 181 illustrations. Published by the H. G. Adair Printing Co., Chicago, Illinois. Price $2.00.

Numerous methods of operating for senile cataract are described by renowned ophthalmologists. The selection of patients, the choice of instruments, the type of anesthesia, the pre- and postoperative care of the patient and many points of interest and practical value are presented. The merits of the intracapsular extraction are emphasized. The illustrations are unusually instructive. There is a great deal of repetition throughout the text.

William M. James.

OBITUARIES

FELIX DE LAPERSONNE

The recent French medical journals bring news of the death of Professor de Lapersonne, early in July, in his 84th year. He suffered from a progressive paralysis that for months prevented his walking, but left his mind active and generally unimpaired. He was born, grew up, and started his medical career at Toulouse. After an interne service there he went to Paris, and became an interne in the Hotel Dieu, and later chief of clinic to Prof. Panas. In 1886 he was made clinical professor of ophthalmology at Lille. After the death of Panas in 1918, he succeeded his former teacher as professor at the Hotel Dieu. His work in these widely separate medical centers of France, his readiness to recognize and collaborate with the work of younger men, and his broad view of his special work and active interest in other branches of medicine, made him in an especial sense the leader of the French ophthalmologists of his time.

His contributions to the literature were important, numerous, well balanced, and leading in the advances of the period. His operation for advancing the levator for ptosis, and his publications on the diagnostic value of lumbar puncture, X-ray studies of the sella turcica in acromegaly, connection of vertical strabismus with head tilting, ocular reaction to tuberculin, ophthalmoplegic migraine, zonular cataract, relation of congenital syphilis to myopia and ophthalmoplegia interna, traumatic hemianopsia, use of foreign protein, typhoid vaccine, ophthalmic organization in the army, and others, were all substantial contributions to the progress of ophthalmology. For 34 years he had served on the scientific board of La Presse Medicale, the semi-weekly, general medical journal of Paris, and took a very active part in this responsible position. In

the issue announcing his death his name stood at the head of their list.

At the International Congress, held in Washington, in 1922, he made the leading address on "The teachings of war, in ocular surgery." He served as vice-president of the Congress, and took an active part in its discussions. In 1931 he was made a Commander of the Legion of Honor and President of the Academy of Medicine; and in 1934 was the first President of the International Congress for the Prevention of Blindness. In 1934 he received from America the Leslie Dana Medal; an honor he shared with Prof. Ernst Fuchs and Priestley Smith.

The tributes written of him abound in such expressions as "Doyen of French and contemporary ophthalmology," "Unusually loved and respected," "The true incarnation of duty," "By the nobleness or his character, the dignity of his life, the constancy of his labors, he honored greatly our science and left us a great example." Edward Jackson.

GIUSEPPI ALBERTOTTI
1851-1936

When an eminent man relinquishes the activities that have made him famous, he passes out of the sphere of action of his colleagues and is soon forgotten. If he should live for many years after his retirement the notice of his death, when it finally comes, is as a voice from the tomb.

Giuseppi Albertotti was a great ophthalmologist of a past generation. To those of to-day his name is recalled only as a memory, or as a frequently repeated authority in the bibliography of research.

Fifteen years ago, having reached the age limit, he was retired from the chair of ophthalmology of the University of Padua to his villa, Monte Sacra, at Rome. Here he employed his wide scholarship in cultural and historical writing.

Albertotti belonged to an age of great men. A consideration of his rich and full life is a lesson and an inspiration to those who seek the success of the moment. He was born in 1851, the year in which Helmholtz gave us the ophthalmoscope. He was laureate in medicine in 1874, so his biographers are probably mistaken when they tell us that he was among the first to introduce the ophthalmoscope in Italy. By that time the instrument had undergone numerous improvements and its use must have been general in Italian clinics. He was for ten years with Raymond in his clinic at Turin, then one of the most noted in Europe. During this time he worked with Mosso and Moleschott in physiology, in the physical laboratory in Naccari, and in general pathology with Bozzozero.

In 1888 he was in Paris in the clinics of de Wecker, of Landolt, and of Panas. In 1880 he had become libera docenza, and by competitive examination in 1884 was made eligible for either of the chairs in ophthalmology of Siena or Piza.

In 1885, on invitation from Manfridi, he became his assistant and associate and again by competitive examination became eligible to the professorship of Modena and Cagliari. Choosing the former he was rapidly advanced to Padua, where he remained until his retirement in 1922. He lived for almost a generation longer to enjoy the scholastic delights of a well-trained mind.

Albertotti was a skillful operator and his diagnostic opinion was a finality with his colleagues.

On the day of his final lecture at Padua his former pupils and friends gathered to do him honor. Among these were Senator Professor Cirincione, Senator Professor Ovio, Professor Speciali of Turin, and Professor Maggiori, then of Sassari, now of Genoa. On that occasion on behalf of the king he was presented

with the Grand Cross of the Crown of Italy.

Professor Albertotti was one of the great masters of whom few remain. To his rare natural gifts, to his patience, his gentleness, and his skill, which was of a high order, was added long and intensive training under the ablest teachers.

From the contemplation of such a life all may profit. Park Lewis.

MAX LYON FOLK
1891-1937

Dr. Folk was born in 1891, in Russia, where he received his early academic training. Moving to Chicago, he was graduated from the Medill High School and in 1917 from the Loyola University College of Medicine. He served as interne for a year and then entered the Army as Lieutenant in the Medical Department. After his discharge, he became connected with the Department of Ophthalmology of the University of Illinois and with the Policlinic. Later, he went to Vienna, where he pursued postgraduate studies in ophthalmology for six months. Rising through the ranks, he was, at his untimely death attending ophthalmologist at Michael Reese Hospital and assistant professor of ophthalmology in the University of Illinois.

Like the majority of short men, Max Folk tended slightly toward corpulence. This accenutated his natural cheerfulness, which made him universally liked. He always appeared immaculate and this personal fastidiousness was reflected in the character of his work. I knew Dr. Folk rather intimately for more than fifteen years and grew to respect his judgment, both ophthalmological and otherwise. He would listen to arguments pro and con, but he had a mind of his own and made his own decisions, which were always on the honorable side of the question.

Dr. Folk was an ardent reader and was well versed in ophthalmic literature. He was not a laboratory man, but leaned toward the side of clinical investigation. Despite the fact that his time was well filled with his private practice and his clinical connections, he wrote and published a fairly large number of papers among which were: Ectopia lentis, Amaurotic family idiocy, Bilateral obstruction of the central retinal artery, Histopathology of holes in the macula, Fundus oculi in diabetes mellitus, and Paracentesis and atropine treatment in optic atrophy.

Dr. Folk died this spring of a gastric adenocarcinoma, leaving a wife, Dr. Martha Rubin Folk, and a son. We shall miss him. Harry S. Gradle.

AN APPRECIATION OF DR. FOLK

The personality of Dr. Max Lyon Folk, as it appeared to his friends and colleagues at the College of Medicine of the University of Illinois, was one of nobility and warmth, of industry and courage. No member of the Eye Staff with whom Dr. Folk had occasion to come in contact, least of all the writer hereof, had aught but praise for him in his dealings with his fellow men and women. His impartiality, no less than his professional ability impressed alike both student and colleague.

An excellent teacher, an intelligent investigator, a wise and sympathetic *doctor*, Max Folk will live long in our memory here.

Hallard Beard.

ABSTRACT DEPARTMENT

EDITED BY DR. WILLIAM H. CRISP

Abstracts are classified under the divisions listed below, which broadly correspond to those formerly used in the Ophthalmic Year Book. It must be remembered that any given paper may belong to several divisions of ophthalmology, although here it is only mentioned in one. Not all of the headings will necessarily be found in any one issue of the Journal.

CLASSIFICATION

1. General methods of diagnosis
2. Therapeutics and operations
3. Physiologic optics, refraction, and color vision
4. Ocular movements
5. Conjunctiva
6. Cornea and sclera
7. Uveal tract, sympathetic disease, and aqueous humor
8. Glaucoma and ocular tension
9. Crystalline lens
10. Retina and vitreous
11. Optic nerve and toxic amblyopias
12. Visual tracts and centers
13. Eyeball and orbit
14. Eyelids and lacrimal apparatus
15. Tumors
16. Injuries
17. Systemic diseases and parasites
18. Hygiene, sociology, education, and history
19. Anatomy, embryology, and comparative ophthalmology

1

GENERAL METHODS OF DIAGNOSIS

Bedell, A. J. **Photography in ophthalmology.** Arch. of Ophth., 1937, v. 17, April, pp. 709-714.

The author discusses the various types of camera and film for ordinary still pictures and for recording defects of ocular motility by motion pictures, and the various factors in obtaining good photographs of the fundus oculi. The films used for each purpose are listed. J. Hewitt Judd.

Bushmich, D. G. **Determination of the size of changes in the fundus.** Viestnik Opht.* 1937, v. 10, pt. 2, p. 251.

The author worked out mathematical tables for calculating the size of the fundus changes by indirect ophthalmoperimetry. Ray K. Daily.

Custodis, E. **The hammer lamp of von Grósz as an ophthalmoscope.** Klin. M. f. Augenh., 1937, v. 98, May, p. 667.

In his ophthalmoscopic courses Custodis found this hammer lamp superior to the ordinary ophthalmoscope, as, even in a light room through a narrow pupil, all details of the fundus could be clearly seen with it. He gives a detailed description with illustration.

C. Zimmermann.

Dashevskii, A. I. **A movable chart for localizing fundus changes.** Viestnik Opht., 1937, v. 10, pt. 2, p. 247.

A description of a mathematical chart devised by the author. (Illustrations.)

Ray K. Daily.

Feldman, J. B. **Dark adaptation as a clinical test; further studies.** Arch. of Ophth., 1937, v. 17, April, pp. 648-661.

The method of study is outlined and the results obtained with 120 patients divided into three groups are presented. In the first group were patients with poor vision due to amblyopia, conical cornea, choroiditis, glaucoma, or retinal detachment. In the second group were patients with diseases of the blood or blood vessels, and in the third group were patients with diseases found to be related to avitaminosis A, metabolic disturbances, calculi of the urinary tract, diabetes mellitus, diseases of the liver or gall bladder, pregnancy, and sterility. Pathologic graphs are often obtained in cases of choroiditis and in a great majority of the cases of glaucoma,, chorioretinitis, and retinal detachment. Patients with arteriosclerosis, avitaminosis A, metabolic disturbances, or calculi of the genito-urinary tract showed

* The reader will notice that, beginning with volume 10, the name of this Russian journal has been changed by omission of the word "Sovietskii."

definite pathologic dark adaptation. Syphilis itself does not affect the dark-adaptation curve. J. Hewitt Judd.

Litinskii, G. A. **Comparative evaluation of the stereomyograph and the depth-perception apparatus, in measuring depth perception.** Viestnik Opht., 1937, v. 10, pt. 1, p. 116, and pt. 2, p. 275.

The stereomyograph and the depth-perception apparatus were devised by the author. The latter possesses greater precision in estimation of depth perception. The comparative study shows the practical adequacy of the stereomyograph. Ray K. Daily.

Oakley, C. L. **Frozen sections of eyes.** Jour. Path. and Bacteriology, 1937, v. 44, March, p. 365.

A satisfactory method of blocking eyes in gelatin and cutting frozen sections is described in detail. Consistently thin sections can be obtained by this method within nine days. There is no dehydration and faded sections can easily be restained. No alcohol is required and sections can be stained for fat.

The disadvantages are that the sections cannot be heated strongly or treated with strong acids, alkalis, or alcohol, and the counterstain fades. The sections have to be mounted in glycerin jelly or Farrant's medium.

Edna M. Reynolds.

Peluse, Samuel. **A new holster for the ophthalmic ward and clinic.** Arch of Ophth., 1937, v. 17, April, pp. 706-708.

A leather holster designed to be carried on the belt is described. It carries ophthalmoscope, pen or pencils, a rule, retinoscope, and pocket flash light. (Photographs.) J. Hewitt Judd.

Shield, J. A. **An aid to facilitate the ophthalmoscopic examination.** Arch. of Ophth., 1937, v. 17, May, pp. 893-894.

The senses of hearing, position, and feeling are utilized to attract the patient's attention so that examination of the fundus is facilitated. This is especially useful in children and psychiatric patients. J. Hewitt Judd.

Simon, Italo. **Rapidity of absorption of collyria in relation to the osmotic pressure of the solution.** Rassegna Ital. d'Ottal., 1936, v. 5, Nov.-Dec., p. 739.

Simon's experiments with collyria of different osmotic pressure show that atropine in hypotonic solution is more rapidly absorbed than in isotonic solution and that maximum mydriasis is obtained earlier. Atropine is always absorbed more slowly in isotonic solution, whether blood or aqueous, than in either hypotonic or hypertonic solutions. The absorption in hypertonic solution behaves differently according to the degree of hypertonicity—thus atropine in a solution of sodium chloride up to 1.37 percent produces a maximum effect, while in solution of 1.06 percent sodium chloride, there is a retarded initial effect but a maximal mydriasis. Eugene M. Blake.

Streiff, E. B. **The action of syntropan in normal and glaucomatous eyes.** Klin. M. f. Augenh., 1937, v. 98, April, p. 504.

At the eye clinic of Geneva a five-percent solution of syntropan has been used experimentally for a year. Within ten minutes two or three drops are instilled three times into the conjunctival sac. Most persons complain of slight burning, which disappears after ten to twenty seconds. Maximal mydriasis is attained after twenty to thirty minutes. Syntropan is especially adapted for ophthalmoscopy and exact examination with the slitlamp, as it does not leave symptoms of glaring and disturbances of accommodation. In glaucoma it is preferable to cocaine for temporary mydriasis, as its effect is also soon neutralized by pilocarpine, and the dilatation of the pupil is greater without epithelial lesions. C. Zimmermann.

2

THERAPEUTICS AND OPERATIONS

Bursuk, G. G. **The modern therapy of ocular infection.** Viestnik Opht., 1937, v. 10, pt. 4, p. 491.

The author traces the experimental stages of investigation into immuno-

therapy in ocular diseases. During the first period investigation was dominated by the thought that in general immunization antibodies penetrate the eye. The second period was dominated by Besredka's idea of local immunity without formation of antibodies. It has finally been demonstrated that local immunity is a part of general immunity, and that penetration of antibodies into the eye is facilitated by the breaking down of the ophthalmo-hematologic barrier by local irritation, such as puncture of the anterior chamber.

Ray K. Daily.

Bursuk, G. G. **Theoretical basis for using immunogen B. in ocular diseases.** Viestnik Opht., 1937, v. 10, pt. 4, p. 500.

An experimental study on rabbits to determine the effectiveness of immunogen B. in raising the agglutinin content. Immunogen B. is a 24-hour mixture of staphylococcus antivirus and an emulsion of leucocytes. The detailed report shows that immunogen B. produces a marked rise in the agglutination index and a leucocytosis proportionate to the number of injections. The action of staphylococcus immunogen B. is specific producing a marked increase of staphylococcus agglutinins and having no effect on B. coli or typhoid agglutinins. The action is especially marked on animals infected with the corresponding micro-organism. Immunogen B. is more effective than its component parts used alone, and more effective than milk. There is no difference between the agglutinin reaction of a local and a remote injection, but during the first day the concentration of agglutinins and the leucocytosis is greatest in the proximity of the injection. This indicates that for the first effect on an inflammatory process the injection should be local. Retrobulbar injection appears most suitable, because it produces no irritative symptoms, and assures a concentration of the local protective forces. Ray K. Daily.

Bursuk, G. G., Zakrzchevskaja, E. I., Schultz, V. A., and Khelle, K. A. **Clinical observations on the use of staphylococcus immunogen B. in purulent ocular affections.** Viestnik Opht., 1937, v. 10, pt. 4, p. 523.

Of 661 patients treated with subcutaneous injections of staphylococcus immunogen B., 137 had corneal ulcers, 90 purulent uveitis, 4 dacryocystitis, 3 phlegmons of the orbit and lid, and 7 blepharitis. 241 patients were given therapeutic injections and 420 prophylactic. In corneal ulcers the effect of staphylococcus immunogen B. was generally favorable. The constitutional reaction was more severe, the local more favorable, and the leuocytosis greater in staphylococcus ulcers. The effect was less marked in mixed staphylococcus and pneumococcus ulcers, and least in pure pneumococcus infections. In traumatic purulent iritis improvement set in two to three days after the first or second injection and healing on the seventeenth day. In traumatic endophthalmitis the results were negative. In purulent uveitis the injections were followed by increased leucocytosis in 68 percent of cases. The injections stimulate the absorption of the exudate, and their effect on the clinical course of the disease was better than that of milk or diphtheria antitoxin.

Ray K. Daily.

Chluser, G. P. **Dicain for superficial anesthesia.** Viestnik Opht., 1937, v. 10, pt. 3, p. 408.

Dicain is the Soviet chemical equivalent of pontocaine. A study of its clinical properties shows that it is stable in solution, stands repeated sterilization, produces rapidly a prolonged anesthesia, does not raise the intraocular tension, and does not injure the corneal epithelium. The author recommends it as a substitute for the imported cocaine.

Ray K. Daily.

Federici, Ermanno. **Recent advances in ocular surgery.** Rassegna Ital. d'Ottal., 1936, v. 5, Nov.-Dec., p. 660.

This is a discourse presented as a prelude to the official course in clinical ophthalmology delivered at the Royal, University of Cagliari. It contains considerable historical matter but little not already known. The author is a strong advocate of intracapsular extraction of

cataract, without iridectomy. In glaucoma he recommends the trephine or an anterior sclerectomy and for retinal detachment, multiple diathermo-coagulation applications.

Eugene M. Blake.

Feldman, J. B. **pH and buffers in relation to ophthalmology.** Arch. of Ophth., 1937, v. 17, May, pp. 797-810.

The methods of obtaining measurements of pH are described and the greater accuracy of the potentiometer is pointed out. With this instrument the Cullen tube can be used for examination of small amounts of tears. The variations in the pH of tears and even of distilled water are discussed. The average range of the pH of tears is between 7 and 7.5. Buffer solutions are defined and various examples of those which may be used in ophthalmology are given. Experiments indicated the advantage of screw-cap or dropper-tip bottles since less variation of pH occurred after prolonged use from these containers. Buffer solutions are mildly antiseptic and are more stable and soothing to the eye than those made with distilled water. Extraocular infection can be counteracted by creating a reaction in the tears which is inhibitive to the growth of bacteria.

J. Hewitt Judd.

Heinsius, E. **Concerning use of ointment containing vitamin A in ophthalmology.** Münch. med. Klin., 1937, v. 84, June 11, pp. 936-937.

In the eye clinic of the University of Berlin ointments containing vitamin A are used in all conditions in which regeneration and growth of the epithelial covering of the eye is desired. A two per cent "Vogan" ointment, whose vitamin A content corresponds to that of good cod-liver oil (about 750 international units), is used from one to three times a day. Beneficial effects have been observed in recurrent corneal erosion, keratitis bullosa, keratitis neuroparalytica, and scrofulous keratoconjunctivitis.

Bertha Klein.

Kasas, I. I. **Osarsol in ocular syphilis.** Viestnik Opht., 1937, v. 10, pt. 3, p. 361.

Osarsol is the Soviet preparation corresponding to stovarsol. The author emphasizes the importance of the administration of mercury and atropine preliminary to any arsenical medication.

Ray K. Daily.

Katz, P. A. **The blood potassium-calcium ratio and the effect of calcium ionization in keratomalacia, uveitis, retinal hemorrhages, maculitis and optic neuritis.** Viestnik Opht., 1937, v. 10, pt. 3, p. 369.

A tabulated report of fifty cases of various ocular diseases treated with calcium ionization. The author considers a high potassium-calcium ratio in the blood an indication for this treatment, because the calcium blood content can not be relied upon to demonstrate a calcium deficiency.

Ray K. Daily.

Kliachko, M. L. **The development of antibodies in the cornea and ocular fluids in response to local immunization.** Viestnik Opht., 1937, v. 10, pt. 3, p. 331.

The objective of this experimental work on rabbits was the demonstration of antibodies in the blood serum, ocular contents, and cornea in response to subconjunctival injections. As irritants the author used staphylococcus immunogen, staphylococcus antivirus, milk, diphtheria antitoxin, and gravidan. The tabulated findings show the appearance and increase of staphylococcus agglutinins in the blood serum, ocular contents, and cornea of the immunized rabbit. In the immunization of one eye agglutinins appear also in the control eye, but the quantity is greater in the immunized eye. The higher agglutination titer in the immunized eye is probably due to the local reaction and local tissue metabolism. Relative to the quantity of agglutinin the staphylococcus immunogen is the most effective of the five substances used.

Ray K. Daily.

Lijo Pavia, J. **Presentation of a blepharostat.** Rev. Oto-Neuro-Oft., 1937, v. 12, April, p. 99; also Arch. de Oft. de Buenos Aires, 1937, v. 12, March, p. 145.

The author has modified the Arruga blepharostat by attaching a lever to the lower arm similar to the one on the upper, making it more adaptable to individual anatomic variations. (Illustrated.) M. Davidson.

Natanson, D. M., Torgovitzkaja, E. V., and Gotlieb, E. S. **Tuberculin therapy of ocular tuberculosis.** Trans. Hirschman Mem. Ophth. Inst., Kharkov, 1935, v. 3, p. 87.

Detailed reports of 26 cases. The authors use tuberculin in allergic as well as in metastatic ocular tuberculosis, and the case reports show good results in early and advanced cases. The erythrocyte sedimentation rate, which the authors regard as indicative of the immunologic state of the patient, was found accelerated in acute and normal in chronic cases. Ray K. Daily.

Nordlow, W. **Stability of cocaine solutions during sterilization.** Acta Ophth., 1937, v. 15, pt. 1, p. 84.

A detailed report of an investigation, in which the anesthetic qualities of cocaine were tested on the human cornea by means of Frey's hair. The conclusions are that repeated boiling of aqueous solutions of cocaine does not impair the anesthetic efficacy; that changes in the pH during boiling in alkali-free glasses are of no significance; and that increase in the pH does not raise the anesthetic effectiveness.
Ray K. Daily.

Pinkerton, F. J. **Surgery of the leprous eye.** Amer. Jour. Ophth., 1937, v. 20, July, pp. 715-720.

Poliak, B. L. **Comparative evaluation of bactericidal substances used in ophthalmology and surgery.** Viestnik Opht., 1937, v. 10, pt. 2, p. 217.

The tabulated report of this laboratory study shows that for bactericidal effect on streptococcus hemolyticus the most effective in aqueous medium are bichloride of mercury, oxycyanide of mercury, and rivanol. In bouillon the most effective are rivanol, ecupin, and magnocide. Zinc sulphate is but slightly effective, and boric acid entirely ineffective. Six-day-old solutions of rivanol, ecupin, optochine, protargol, and collargol are less bactericidal than fresh solutions. Ray K. Daily.

Poliak, B. L. **Further observations on the effect of gravidan on ocular disease.** Viestnik Opht., 1937, v. 10, pt. 1, p. 49.

An analysis of 118 cases treated with gravidan. Endocrine disturbances were found in 23 percent of ocular diseases, being particularly frequent in retinitis pigmentosa. Disturbances in the neurovegetative apparatus were also frequent, usually in the form of sympathetic irritability. Gravidan was very effective as a stimulant to local therapy in scrofulosis, in iritis and iridocyclitis, in some types of corneal ulcer, and in postoperative endophthalmitis. No objective improvement was obtained in retinitis pigmentosa or in parenchymatous keratitis: inadequate dosage, however, may have been a factor in the negative response. The marked improvement in general condition consisted in disappearance of symptoms of endocrine and neurovegetative dysfunction. Ray K. Daily.

Rachevskii, F. A. **Vitamin therapy in ophthalmology.** Viestnik Opht., 1937, v. 10, pt. 1, p. 63.

A review of the literature.
Ray K. Daily.

Richards, G. E. **Radiotherapy in lesions about the eye.** Amer. Jour. Roentgenology and Radium Therapy, 1936, v. 36, Nov., p. 588.

In order of frequency, the evil consequences of radiotherapy about the eye are corneal ulcer, secondary glaucoma, and cataract. Benign lesions which respond to this type of treatment are blepharitis, eczema of the lids, inverted lashes, papilloma, vernal catarrh, keratosis, nevus, and angioma. Malignant lesions responding are rodent ulcer, epithelioma, and intraocular neoplasms. Radiotherapy is used also in hyperplasia of the corneal epithelium and cataract. Theodore M. Shapira.

Testa, Ugo. **The miotic effect of pilocarpine upon medical mydriasis.** Ras-

segna Ital. d'Ottal., 1936, v. 5, Nov.-Dec., p. 680.

Testa states that a six-percent solution of pilocarpine chloride is the optimum concentration for absorption by the cornea and that in normal eyes it produces a more prompt and complete miosis than a two-percent solution. In glaucoma the stronger solution is well tolerated, produces no toxic effects, and reduces intraocular tension more quickly and more completely. He tested the relative powers of two-percent and six-percent solutions of pilocarpine to overcome the mydriasis produced by a one-percent solution of atropine and that produced by a five-percent solution of euphthalmine. He concludes that the stronger concentration is no more effective in overcoming atropine mydriasis but much more active against euphthalmine. Eugene M. Blake.

Ukolova, M. A., and Khayoutin, S. M. **The importance of metabolism determination in the therapy of ocular diseases.** Viestnik Opht., 1937, v. 10, pt. 4, p. 596.

A study of the metabolic rate of sixty cases of various ocular infections. The tabulated findings showed an increased metabolic rate in retinitis pigmentosa and in chorioretinitis. In inflammatory lesions the metabolism was high in some cases and low in others. It was unchanged in cataract and optic atrophy, and was found increased in one case of choked disc due to brain tumor. It varied widely in glaucoma. Under small doses of insulin the increased metabolic rate in retinitis pigmentosa came down to normal, and visual acuity was improved. These findings lead the author to conclude that a study of the metabolic rate and its normalization through appropriate measures is indicated in ocular diseases.

Ray K. Daily.

3

PHYSIOLOGIC OPTICS, REFRACTION, AND COLOR VISION

Bielostotski, E. M., and Ilina, S. A. **The effect of vestibular stimulation on color perception.** Viestnik Opht., 1937, v. 10, pt. 1, p. 135.

The tabulated and graphic report shows a diminution in color perception through vestibular stimulation. The greatest effect is produced by stimulation of the vertical semicircular canals and the least by the horizontal.

Ray K. Daily.

Bothman, Louis. **Refractive errors in the same eyes under scopolamine and under atropine cycloplegia.** Amer. Jour. Ophth., 1937, v. 20, Aug., pp. 822-826.

Bröns, J. **Physiologic irradiation or propagation, as a cause of negative after images.** Acta Ophth., 1937, v. 15, pt. 2, p. 137.

The author describes a device which he uses for the study of negative after images. He regards negative after images as a propagation phenomenon which occurs later and is of longer duration than the retinal impression provoked by direct stimulation. (Illustrations.) Ray K. Daily.

Dashevskii, A. I., and Saretzkaja, R. G. **Methods of studying ocular fatigue.** Trans. Hirschman Mem. Ophth. Inst., Kharkov, 1935, v. 3, p. 153.

The effect of two hours of reading on accommodation, muscle balance, visual acuity, and winking frequency was studied on six school girls. The percentages given appear to be of very little value in view of the small number of individuals dealt with.

Ray K. Daily.

Elsberg, C. A., and Spotnitz, H. **Some neural components of the visual response.** Amer. Jour. of Physiology, 1937, v. 118, April 1, p. 792.

This article does not lend itself well to abstracting because of the numerous physico-mathematical formulae.

Theodore M. Shapira.

Gassovskii, L. H., and Nikolskaja. N. A. **The effect of light adaptation on speed of recognition of a small light source of low intensity.** Viestnik Opht., 1937, v. 10, pt. 1, p. 124.

The detailed and graphic report of this study in physiologic optics shows that the time required for recognition

of a small luminous point of low intensity rises with the intensity of the light-adaptation field. The time is lowered with increase in the intensity of the luminous point. Ray K. Daily.

Gertz, Hans. **A new method for the reduction of dioptric formulae.** Acta Ophth., 1937, v. 15, pt. 2, p. 179.

A mathematical study which does not lend itself to abstracting.

Ray K. Daily.

Iofe, Z. M. **Depth perception in anisometropia.** Viestnik Opht., 1937, v. 10, pt. 3, p. 423.

The material consisted of 80 students with anisometropia, and the tests were made with the Litinsky stereomyograph. Eleven percent had poor depth perception for near and twenty-five percent for distance. Depth perception is conditioned not by the sum of but by the difference in the visual acuity in the two eyes. With normal visual acuity in one eye a visual acuity lower than .4 in the other eye impairs depth perception for near, more so for distance. Visual acuity above .4 in the poorer eye does not impair depth perception. The degree of anisometropia and refraction does not affect depth perception.

Ray K. Daily.

Kotlarevskaja, S. Z. **Clinical studies in color vision.** Viestnik Opht., 1937, v. 10, pt. 3, p. 401.

The object of this study was to evaluate Schaff's mosaic plates in the testing of color blindness. The findings show that these plates are less sensitive than the Ishihara or Stilling plates.

Ray K. Daily.

Kraskin, S. Z. **Proper equipment in test lenses.** Viestnik Opht., 1937, v. 10, pt. 2, p. 281.

A description of a trial case manufactured in Russia. (Illustrations.)

Ray K. Daily.

Kravkov, S. V. **The effect of sound on Rayleigh's level.** Viestnik Opht., 1937, v. 10, pt. 1, p. 121.

The data of this study show the influence of sound on color perception to be slight. The shift in the curve is in the direction of protanomaly.

Ray K. Daily.

Macgillivray, A. M., and Macleod, A. S. **Congenital total color blindness.** Lancet, 1936, v. 2, Sept. 12, p. 626.

The author reports an unusual case of complete congenital color blindness. The case record is given in detail.

M. E. Marcove.

Manunza, Paolo. **Right-handedness, left-handedness, and ocular dominance.** Rassegna Ital. d'Ottal., 1936, v. 5, Sept.-Oct., p. 511.

The tests employed by the author were (1) cutting out with large scissors an irregular pencil line on thin paper, (2) sharpening a toothpick with a safety-razor blade, and (3) pointing a pistol. He concludes that ocular dominance is an element of functional supremacy of central and not peripheral origin. In the superior arts the right-handed are almost always right-eyed and vice versa. The same percentage of handedness pertains among the congenitally blind as among seeing individuals. There are no definite reasons for asserting that the axis of vision of the object fixed is displaced to the right or left of the sagittal plane, corresponding to the side of the dominant eye. About 75 percent of all persons are right-handed (and not 95 percent as often stated), 5 percent are left-handed, and 20 percent are indifferent. These figures hold fairly accurately for children as well as adults. Education and habits have nothing to do with dextrality or sinistrality which are entirely of congenital origin. (10 figures.)

Eugene M. Blake.

Mazzei, Amedo. **Do myopes with healthy fundi obtain as clear images as emmetropes?** Rassegna Ital. d'Ottal., 1936, v. 5, Sept.-Oct., p. 580.

From special studies Mazzei concludes that individuals with four to five diopters of myopia without fundus lesions and with refractive correction obtain 10/10 vision but that the clearness of the characters is not equal to that of emmetropes. He believes that the re-

duction in acuity of vision is related to the enlarged pupils and that it is not possible, practically, to modify the size of the pupils, which is, presumably, due to an imperfect physico-chemical equilibrium of the sensory elements.

Eugene M. Blake.

Musilev, F. I. **The influence of the distance of the object on visual acuity.** Viestnik Opht., 1937, v. 10, pt. 2, p. 266.

This experimental study seeks to explain the Aubert-Foerster and the Freeman visual-acuity phenomena. The author concludes that the better visual acuity for small near objects found by Aubert-Foerster is attributable to experimental inconsistency in the relation of the angle subtended by the objects and the brightness of the background. The diminution in visual acuity observed by Freeman the author ascribes to the effect of excessive convergence.

Ray K. Daily.

Pacalin, G. **Stereoscopic vision without a stereoscope.** Ann. d'Ocul., 1937, v. 174, Jan., pp. 49-55.

Circular diagrams have been devised which, when observed with both eyes, give a definite sensation of depth. Pacalin concludes from a study of these models that binocular vision of relief is due to parallactic displacement alone and not to fusion of images.

John C. Long.

Rabkin, E. B. **Polychromatic plates for diagnosis of color blindness.** Trans. Hirschman Mem. Ophth. Inst., Kharkov, 1935, v. 3, p. 15.

The author's color-test plates, checked by the Nagel anomaloscope, permit differential diagnosis of color anomalies beyond that obtainable with Stilling or Ishihara plates.

Ray K. Daily.

Regan, J. J. **Astigmatic dials in refined refraction.** Arch. of Ophth., 1937, v. 17, May, pp. 788-796.

The author's modifications of the Lancaster astigmatic dials are described and their use illustrated by means of a series of experiments. Proper fogging is necessary before correct estimates can be made with the astigmatic charts. Several difficulties encountered in the use of these charts are discussed.

J. Hewitt Judd.

Robertson, C. J. **Effect of fatigue on the adjustment of the eye to near and far vision.** Arch of Ophth., 1937, v. 17, May, pp. 859-876.

This report adds to the previously reported measurements with the tachistoscope of the speed of adjustment of the eye to near and far vision. The data of tests of the dynamic speed of vision for pilots with fatigue after 1, 2, 3, and 4 hours of flying are tabulated and compared with the normal standards. Age and various anomalous conditions of the eye have a marked bearing on the speed of adjustment. Fatigue has a great effect on the speed of adjustment at all ages, but more marked as age advances. J. Hewitt Judd.

Schumacher, Gerhard. **The behavior of the monocular and binocular threshold of perception during dark adaptation in light and darkness.** Acta Ophth., 1937, v. 15, pt. 1, p. 5.

A review of the literature and a report of the author's own investigations using red light as a stimulus. The data show the presence of binocular summation for the threshold of perception, increasing with the state of dark adaptation, and an absence of summation in daylight. The degree of binocular summation parallels the difference in the threshold of perception in daylight and in dark adaptation: the further apart the thresholds of perception the greater the binocular summation. In the same state of adaptation the binocular summation is greater when white light is used as a stimulus than when red light is used. The apparatus for daylight perception has an inhibitory action on the mechanism for dark adaptation.

Ray K. Daily.

Tron, E. **High myopia with good correction.** Viestnik Opht., 1937, v. 10, pt. 1, p. 19.

A review of the literature and a detailed report of the author's own investigations relative to the physiologic

optics of myopia and the causes of poor vision. The material consisted of six high myopes with good visual acuity and nine high myopes with poor visual acuity. Detailed analysis shows that the wide variation in visual acuity cannot be explained by length of axis, fundus changes, or refractive power. The author believes that the variation may be due to difference in diameter of the cones in the retina. Ray K. Daily.

4

OCULAR MOVEMENTS

Bothman, Louis. **Burning; a symptom of vertical phoria.** Amer. Jour. Ophth., 1937, v. 20, July, pp. 740-741.

Boyd, Lindsay. **Miners' nystagmus.** Trans. Ophth. Soc. United Kingdom, 1936, v. 56, p. 348.

To correctly call the condition miners' nystagmus, the author considers oscillations necessary, otherwise it is miners' psychoneurosis. In regard to treatment he advises surface work at once, care of general health, and symptomatic medical treatment.

Beulah Cushman.

Butler, T. H. **The simple treatment of convergent strabismus.** Trans. Ophth. Soc. United Kingdom, 1936, v. 56, p. 357.

Beginning complete and prolonged occlusion of the better eye before the age of eight years, the author found 70 percent of girls and 50 percent of boys were cured. The error of refraction is corrected and orthoptic exercises used. For operative treatment, the optimum age is eight years, as a child of this age has enough intelligence for operation without general anesthesia.

Perforation of the globe by the scleral sutures occurred in three cases during thirtv years of experience. In the first two a drop of blood appeared in the anterior chamber while inserting the stitch. In the third case, while pulling the advancement suture through the iris was drawn along with it. The suture was cut off but left a complete iridectomy. In another eye, panophthalmitis was attributed to the use of catgut sutures, as no perforation was found upon microscopic examination.

Beulah Cushman.

Butler, T. H., and Wilson, A. J. **Ocular paralysis following mumps.** Brit. Med. Jour., 1937, April 10, p. 752. (See Section 17, Systemic diseases and parasites.)

Fenn, W. O., and Hursh, J. B. **Movements of the eyes when the lids are closed.** Amer. Jour. Physiology, 1937, v. 118, Jan. 1, p. 8.

Eye movements are recorded by means of a string galvanometer connected to electrodes on either side of the head lateral to the eyes. When the head is moved rapidly to the right and left with closed eyes, three types of movement are recorded: (1) perfect fixation as when the eyes are open, (2) partial nystagmoid fixation in which quick overtaking movements of the eyes interrupt the nystagmus, (3) movement of the eyes in advance of the head as when one looks with the eyes open from one side to the other.

Theodore M. Shapira.

Glover, L. P. **Congenital nystagmus.** Arch. of Ophth., 1937, v. 17, April, pp. 705-706.

Two cases are reported from a family of four generations showing hereditary nystagmus. Head nodding was not present but one patient held the head back to compensate for the nystagmus. Apparently females transmit the disease but are not susceptible.

J. Hewitt Judd.

Gutzeit, R. **Tendon spreader for facilitating muscular advancement.** Klin. M. f. Augenh., 1937, v. 98, May, p. 671.

With reference to the article by Streiff (see Amer. Jour. Ophth., 1937, v. 20, p. 659.) Gutzeit says that he found a similar instrument invented by Schweigger and manufactured by Wurach of Berlin, very satisfactory.

C. Zimmermann.

Strebel, J. **Esophoria and anaphoria in twin sisters.** Klin. M. f. Augenh., 1937, v. 98, June, p. 788.

Both complained of frontal headache and dizziness in doing close work. This disappeared when covering the right hyperphoric eye. Since prisms gave no relief, phorometrically controlled tenotomies of the upper half of the internal rectus and the nasal half of the superior rectus were performed. Complete subsidence of the symptoms followed.

C. Zimmermann.

5

CONJUNCTIVA

Birch-Hirschfeld. **The most important pathologic alterations caused by trachoma at an advanced stage.** Rev. Internat. du Trachome, 1937, v. 14, Jan., p. 13.

The author sets forth in detail the changes in the conjunctiva and tarsus that occur in advanced stages of trachoma. He states that one is reduced to mere hypotheses in regard to the causes of the infiltrations and subsequent scar-tissue formation that occur in trachoma. However, anatomic observation at an advanced stage is important to enable one to judge the severity of the disease and the treatment to be applied. Early energetic treatment is stressed. When the tarsus is involved in the advanced stage, its removal may prevent relapses.

J. Wesley McKinney.

Clark, W. B. **The treatment of seborrheic blepharoconjunctivitis.** Amer. Jour. Ophth., 1937, v. 20, Aug., pp. 808-811.

Cuenod, A., and Nataf, R. **Bacteriologic and experimental researches on the etiology of trachoma.** Brit. Jour. Ophth., 1937, v. 21, June, pp. 309-315. (See Amer. Jour. Ophth., 1937, v. 20, Aug., p. 862.)

Frattini, P. G. **An unusual form of syphilis of the bulbar conjunctiva.** Rassegna Ital. d'Ottal., 1936, Sept.-Oct., v. 5, p. 616.

In a woman of 72 years whose syphilitic infection dated back 42 years, there developed a diffuse syphiloma of the bulbar conjunctiva of the right eye. The patient had not previously had constitutional treatment, and the eye lesion appeared soon after this was begun. There was prompt response to specific treatment. Histologically one saw swollen cylindric epithelial cells on the surface, a connective tissue rich in blood vessels with well formed walls, and many lymphocytes and plasmocytes. The latter were densest about the vessels. No epithelial masses or giant cells were seen. The author adds a review of the literature on syphilis of the external parts of the eye. (3 figures.)

Eugene M. Blake.

Goldfeder, A. E. **The technique of my method of cartilage implantation in trachoma.** Trans. Hirschman Mem. Ophth. Inst., Kharkov, 1935, v. 3, p. 121.

The author believes that his method of implanting a strip of auricular cartilage above the limbus has the following advantages over Denig's operation: The technique is simple. There is no wound in the mouth. The cartilage does not become necrotic and is not subject to invasion by the trachomatous process. Within a very short time it is indistinguishable in color from the sclera, and it is more pleasing cosmetically than mucous membrane or skin. (Illustrations.)

Ray K. Daily.

Julianelle, L. A., Harrison, R. W., and Morris, M. C. **The probable nature of the infectious agent of trachoma.** Jour. Exper. Med., 1937, v. 65, May 1, p. 735.

The results of experimental work over a period of six years are reported. A state of malnutrition does not predispose monkeys to trachoma. An elaborate study of the bacteria cultivable from the disease proves that trachoma is not characterized by any particular flora since the same bacteria may be isolated in similar frequency from other eye conditions and to a less extent from normal eyes. The infectious agent of trachoma can be freed from extraneous bacteria by passage through rabbit testicle. It is possible to infect monkeys with experimental trachoma with material completely liberated from extraneous bacteria. Filtration experi-

ments confirmed the general observation that the infectious agent is filterable with difficulty. Tissue-culture experiments proved uniformly unsuccessful in the cultivation of the agent. The evidence suggests that the infectious agent of trachoma is a virus of an extremely unusual variety.

Edna M. Reynolds.

Kwaskowski, Adam. **The slitlamp appearance of the limbus in trachoma and conjunctivitis.** Klinika Oczna, 1937, v. 15, pt. 1, p. 97.

A study of the limbus in 22 cases of trachoma in various stages, and in 11 cases of follicular and 6 cases of chronic conjunctivitis. The author concludes that diagnosis of trachoma may be made by the slitlamp appearance of the vessels at the limbus, and recommends examination of the limbus in yellow light in which the blood vessels stand out as dark streaks on a yellow background. Ray K. Daily.

Lundberg, Ake. **A few cases of allergic conjunctivitis in patients with urticaria.** Acta Ophth., 1937, v. 15, pt. 1, p. 60.

A report of two cases, one of edematous conjunctivitis and one of the nodular type. The former was a contact conjunctivitis caused by contact with a crab shell in a patient sensitive to crabs and lobster. The nodular type of allergic conjunctivitis occurred in a patient suffering from erythema nodosum and the allergic nature of the conjunctivitis was determined microscopically. (Photomicrographs.) Ray K. Daily.

Martinez, E. S. **Autohemotherapy, the subconjunctival route in the treatment of trachoma.** Rev. Internat. du Trachome, 1937, v. 14, Jan., p. 19.

The writer reports two cases of trachoma with rather pronounced symptoms and active pannus, in which autohemotherapy was used with benefit. The patient's blood (0.3 c.c.) was injected beneath the conjunctiva of the upper fornix. There was regression of the pannus and marked relief of symptoms. Reaction was negligible.

J. Wesley McKinney.

Massaud, Farid. **The constitutional side in the pathology and treatment of trachoma.** Rev. Internat. du Trachome, 1937, v. 14, Jan. p. 42.

The author elaborates upon a number of interesting observations. Certain individuals and certain groups of people seem to be immune to trachoma. Certain other individuals and groups seem to be especially susceptible and to develop a very severe form. The effect of personal hygiene and of certain foods which cause particular susceptibility of mucous membranes to infection is considered. Some constitutional phases of experimental trachoma are discussed. The whole question is summarized under the heading of proper treatment, balanced diet, and proper hygienic conditions. J. Wesley McKinney.

Mathis, Giovanni. **The gonoreaction in conjunctival blennorrhagia.** Rassegna Ital. d'Ottal., 1936, v. 5, Nov.-Dec., p. 706.

The author presents the results of his study of the gonoreaction upon blood serum in various forms of gonorrheal infection and describes the technique employed. He found that the antibody is not transferred from mother to child. In non-specific cases the reaction is negative and also in those treated promptly. It is positive in some particularly grave cases after the gonococcus has disappeared from the secretion. The medicolegal value of the test is emphasized. Fourteen cases are reported in detail to demonstrate the various reactions to the test.

Eugene M. Blake.

Pavlov, H. M. **Bacteriologic conjunctival studies in the Merv district.** Viestnik Opht., 1937, v. 10, pt. 2, p. 230.

In Turkmen in Central Asia, acute epidemic conjunctivitis during the summer months is so prevalent that it disorganizes the cotton and silk industries. During the height of the epidemic children six or seven years old frequently develop severe corneal complications. Bacteriologic studies show that such cases are gonorrheal in etiology; yet in spite of close contact and lack of hygienic measures the mothers never

catch the infection from their children. In order to determine the characteristics of this type of gonorrheal conjunctivitis five hundred conjunctival smears were taken during the winter, when the epidemic was over. This study demonstrated the presence of Koch-Weeks bacillus in 6 percent of the cases, gonococcus in 16 percent, the Morax-Axenfeld diplobacillus in 30 percent, the Morax-Axenfeld bacillus associated with the staphylococcus in 10 percent, gram-positive intracellular diplococcus in 25 percent, staphylococcus in 9 percent, and no bacterium in 4 percent. A large proportion of the population are thus carriers of infection, which flares up into acute conjunctivitis in the warm months. A special research commission is being organized to deal with the problem. Ray K. Daily.

Soloninkin, D. S. **Emollator in the therapy of trachoma.** Viestnik Opht., 1937, v. 10, pt. 1, p. 113.

A description of a new device for expression of trachoma granules. (Illustrations.) Ray K. Daily.

Stepanova, H. B., Asarova, N. S., and Goldfeder, A. E. **Biologic method of demonstrating Bacillus granulosis.** Trans. Hirschman Ophth. Inst., Kharkov, 1935, v. 3, p. 116.

A suspension of trachoma follicles in physiologic saline was injected into the testis of a rabbit. Four or five days later the testis was extirpated, ground, and mixed with Tirode's medium. The mixture was then used for inoculation on various culture media and for further injection into rabbit testis. The material was mainly collected during a rural survey of trachoma cases, and was kept in sealed ampoules for one month and a half before the laboratory studies were made. Of 32 cases studied Bacillus granulosis was demonstrated in 24.

Ray K. Daily.

Thygeson, Phillips. **Bacteriologic differentiation of the common forms of conjunctivitis, with particular reference to types prevailing in Iowa.** Jour. Iowa State Med. Soc., 1937, v. 27, Jan., p. 15.

Thygeson says that the most common cause of hyperacute conjunctivitis is the gonococcus. The acute and subacute forms are due to the pneumococcus, the chronic forms to the staphylococcus aureus. Staphylococcus aureus was found to be the cause of conjunctivitis of the new born in 51.7 percent of 261 cases, pneumococcus in 13 percent, and inclusion virus in 8.8 percent. Allergic conjunctivitis was encountered in 24 cases. The most common type of bacteria found in conjunctivitis secondary to dacryocystitis was the pneumococcus, with the influenza bacillus second. Of the special forms of conjunctivitis, trachoma occurred most frequently.

Theodore M. Shapira.

Trapezontzeva, C. **On the filtrability and the filtrable elements of Bacterium granulosis Noguchi.** Rev. Internat. du Trachome, 1937, v. 14, Jan., p. 30.

The author describes a gram-negative bacillus containing gram-positive granules in association with Bacterium granulosis Noguchi. He also describes a filtrable element associated with this bacterium. No attempt is made to attach significance to these elements. J. Wesley McKinney.

Trapezontzeva, E. **Trachoma and Bacillus granulosis Noguchi.** Viestnik Opht., 1937, v. 10, pt. 1, p. 103.

Analysis of results in 200 cases of Noguchi's complement fixation test for trachoma. The test was positive in 34.5 percent cases of trachoma in the first stage, 75 percent in the second stage, and 51.8 percent in the third stage.

Ray K. Daily.

6

CORNEA AND SCLERA

Alajmo, Biagio. **Diathermocoagulation in the treatment of keratoconus.** Rassegna Ital. d'Ottal., 1936, v. 5, Nov.-Dec., p. 654.

After a discussion of the causes and treatment of keratoconus, Alajmo describes an original method of therapy which has yielded excellent results in his hands. He employs non-perforating application of the diathermocoagulation current, using a spherical electrode, from 1 to 1.5 mm. in diameter. This is

attached to the positive pole and the negative plate is fastened to the leg or neck. A current of 50 to 60 ma. is passed for from one to two seconds. The resulting opacity at the apex of the corneal cone appears at once and radiates outward into the stroma for a short distance. The opacity decreases in a short time and becomes almost invisible. The flattening of the cone is immediate and there is no reaction from the treatment. Six cases are reported showing marked improvement in vision and a great reduction of astigmatism.

Eugene M. Blake.

Archangelskii, P. F. **Biomicroscopy of the eye after transplantation of cartilage and epidermis.** Viestnik Opht., 1937, v. 10, pt. 2, p. 214.

The author attributes the effect of the Goldfeder operation on pannus to the affinity of the blood vessels for the implanted material and away from the cornea. (Illustrations.)

Ray K. Daily.

Awerbach, M. I. **Suggestions for the use of cadaver cornea for keratoplasty.** Viestnik Opht., 1937, v. 10, pt. 3, p. 345.

To fasten the corneal transplant the author uses a conjunctival band from the cadaver eye, which he attaches to the conjunctiva at the limbus of the living eye. This does away with mutilation of the conjunctiva.

Ray K. Daily.

Blaauw, E. E. **On cyclic chronic edema of the cornea.** Klin. M. f. Augenh., 1937, v. 98, May, p. 665.

A patient complained that for a month he had experienced indistinct vision after awaking, the condition disappearing in the afternoon. There was an opacity of the lower temporal quadrant of the cornea in the epithelium and subjacent parenchyma, with fine epithelial vacuolization. Tension was normal. In about seven months the patient returned. After shoveling snow his eye became irritated. The cornea showed vesicles in the epithelium, giving the impression of acute herpes zoster. Curettement of the epithelium aggravated the irritation for a time, but after six months the condition was satisfactory. The author attributes the disease to infection by herpes virus.

C. Zimmermann.

Bursuk, G. G. **Experiments with therapeutic immunization with staphylococcus immunogen B.** Viestnik Opht., 1937, v. 10, pt. 4, p. 517.

A detailed report of an experimental study on rabbits. Experimental staphylococcus corneal ulcers were treated by injections of staphylococcus immunogen B. The first injection was retrobulbar and the subsequent subcutaneous. The results indicate that promptly after institution of these injections there occurs a decided turn for the better in the clinical course of the ulcer, and in spite of the marked corneal destruction absorption of the infiltrate and recession of the inflammatory symptoms are rapid. Ray K. Daily.

Coppez, Leon. **Resistance of the cornea to heat.** Bull. Soc. Franç. d'Opht., 1936, v. 49, pp. 93-101.

While thermocautery remains the treatment of choice in ulcer of the cornea, the author of this article points out that with the usual methods the temperature cannot be readily controlled, the whole eyeball is more or less heated, and scars result. As opposed to cautery the author recommends the method of coagulation diathermy applied by means of a pyrometric electrode, which has the advantage of producing heat locally in the cornea, the instrument itself remaining cold. To compare cauterization by heat with the action of the coagulation diathermy electrode the author produces the same amount of temperature by each method, using a single instrument which acts in one case as an electrode for diathermy and in the other case as a cautery. The action of the coagulation electrode is much less traumatic, leaves only a very faintly perceptible scar, extends much deeper in the cornea, and should be a more effective means of sterilization. Clarence W. Rainey.

Filatov, V. P. **Transplantation of the cornea from preserved cadavers' eyes.**

Lancet, 1937, v. 1, June 12, p. 1395. (See Amer. Jour. Ophth., 1936, v. 19, Aug., p. 728.)

Fischer, F. P. **Greater frequency of corneal herpes in men.** Acta Ophth., 1937, v. 15, pt. 1, p. 73.

A statistical study of 267 cases of herpetic keratitis. An outstanding feature of the material is the greater frequency of this disease in men, and in the urban population. Because of the poverty in vitamin A of the diet of the urban population, the author attributes this disease to an A-avitaminosis.

Ray K. Daily.

Franceschetti and Kiewe. **Corneal graft in a case of familial degeneration of the cornea.** Bull. Soc. Franç. d'Opht., 1936, v. 49, pp. 102-106.

The authors performed non-perforating bilateral keratoplasty upon a 38-year-old male patient suffering from recurrent inflammation of the corneae. Both corneae were opaque due to the presence of nodular alteration in the parenchyma. The condition had occurred in seven members in three successive generations of the patient's family. The right vision was 4/50 and the left vision 3/40 before the operation. The corneal transplants were obtained by means of the von Hippel trephine and remained clear. The vision improved to 5/10 in the right eye and in the left eye to 5/7.5 with correction. Non-perforating keratoplasty is recommended for other types of corneal degeneration. Clarence W. Rainey.

Frazer, A. D. **One hundred cases of interstitial keratitis.** Trans. Ophth. Soc. United Kingdom, 1936, v. 56, p. 354.

The author found injury apparently the exciting factor in development of interstitial keratitis in two to three percent of the cases. In seventy cases both eyes were affected on first examination. In nine percent of the cases relapse occurred after treatment was started. The average time required for cases to quiet and the cornea to become almost clear was sixteen weeks. The blood-Wassermann reaction was positive in 95.6 percent of the cases on first examination. In over one hundred cases treated for a year or more 57 percent were still positive. The cerebrospinal fluid was negative in 41 cases. Beulah Cushman.

Gasteiger, H. **Senile degeneration of the sclera at insertion of the ocular muscles.** Klin. M. f. Augenh., 1937, v. 98, June, p. 767.

A woman of 78 years presented in the temporal and nasal parts of the right sclera vertical glassy bands, 1.5 to 2 mm. wide and 4 to 6 mm. long, bordered toward the cornea by a sharp straight line, peripherally by a slightly indented line; also at the insertion of the inferior rectus a small horizontal band was visible. The slitlamp showed that the indentations were created by tendinous fibers of the muscles, in whose immediate neighborhood the bands lay. The left eye presented a similar condition, with the exception of the lower band. Transillumination of the temporal bands in each eye yielded a slight red light.

By dehydration of pigs' eyes with glycerin (87 percent) a glassy alteration of the whole sclera was produced. Painting with glycerin produced circumscribed band-like dehydrations, which disappeared after the eyes had been placed in water or salt solution for a few minutes. These experiments and the observations from literature prove that the described changes were caused by dehydration. (Illustrations.)

C. Zimmermann.

Jauernig, Gottfried. **Cylindrical bulging and attenuation of the lower half of the cornea.** Klin. M. f. Augenh., 1937, v. 98, May, p. 592.

A woman of sixty years presented a progressive bulging of the lower attenuated half of each cornea, caused by malnutrition of Descemet's membrane probably of luetic origin. Pressure by the lids was supposed to have had an additional deleterious effect. Production of a solid scar by cauterization of the affected part and covering by a conjunctival flap proved to be of value. (Illustrations.) C. Zimmerman.

Kopp, I. F. **The first series of corneal transplantations.** Viestnik Opht., 1937, v. 10, pt. 3, p. 347.

A detailed review of eleven cases of corneal transplantation, of which five have permanent transparent transplants. The author concludes that for a successful result the presence of normal corneal fibers in the scar is essential; that anterior synechia is the cause of opacification of the transplant and if present should be eliminated by a preliminary iridectomy; and that the disease causing the corneal opacity must have run its course before transplantation is attempted. The author reports an interesting case of local immunity, in which the transplant remained uninvolved during a severe attack of scrofulous keratitis. (Illustrations.) Ray K. Daily.

Krümmel, H. **On keratitis pustuliformis profunda.** Klin. M. f. Augenh., 1937, v. 98, May, p. 601.

The right cornea of a man of 34 years, who had lost his left eye ten years previously by accident, presented roundish well defined yellowish-gray infiltrations in the intermediate and deep layers of the parenchyma, precipitates on Descemet's membrane, iritis, hypopyon and dense opacity of the aqueous. Vision was reduced to 1/15. The patient had had a chancre seventeen years previously. Antisyphilitic treatment effected considerable improvement. After five weeks the eye was free of irritation and vision was normal. The difference between hereditary and acquired lues of the cornea in morphology and in yielding to therapeutic influences is remarkable. This acquired type is rare and was first described by E. Fuchs. The mode of infection of the cornea, whether from the blood current through ciliary body, iris, aqueous, or marginal loops, has not been ascertained. (One illustration.) C. Zimmermann.

Marbaix and Appelmans. **Punctate keratitis of filarial origin.** Bull. Soc. Franç. d'Opht., 1936, v. 49, pp. 74-84. (See Section 17, Systemic diseases and parasites.)

Marmalevskii, K. V. **A square-shaped corneal transplant.** Viestnik Opht., 1937, v. 10, pt. 3, p. 358.

The flap is outlined by placing on the cornea a piece of sterile transparent paper or egg membrane, and the incision is made with a narrow Graefe knife. Ray K. Daily.

Mauksch, H. **Pollen allergy as a cause of superficial keratitis.** Zeit. f. Augenh., 1937, v. 91, April, p. 343.

This patient first noticed severe swelling of his lids and photophobia after a walk through fields in May, 1918. Ulcers were diagnosed which quickly responded to treatment. The ulcers recurred the following May, but it was October before the eyes healed. Each May the manifestations became more severe and finally a pannus as in eczematous keratitis developed. The patient did not react to skin tests with pollens, and the author did not care to risk introducing pollen into the eyes in periods of quiescence. Once, however, in winter after an early thaw, hazel shrubs bloomed and filled the air with pollen to which the patient immediately reacted with severe keratitis.

During the summer of 1930 which he spent in East Prussia among vegetation entirely different from that near his home, his eyes healed completely. Immediately on his return home the trouble recurred. Finally the patient was desensitized by the method of Strebel and the eyes healed remarkably. The pannus gradually cleared so that the patient regained moderately useful vision. There can be little doubt that the corneal lesion was allergic.
F. Herbert Haessler.

Mescherskii, H. H. **Carotin in the therapy of herpetic keratitis.** Viestnik Opht., 1937, v. 10, pt. 3, p. 419.

A report of ten cases in which carotin instilled locally hastened regeneration of the corneal epithelium. Carotin has analgesic and keratoplastic properties and has no deleterious effect on adjacent tissues. Ray K. Daily.

Neame, Humphrey. **The association of dendritic ulcer of the cornea and of**

superficial punctate keratitis with herpes facialis. Brit. Jour. Ophth., 1937, v. 21, June, pp. 298-309.

By study of three cases, the author reaches the conclusion that one virus, subject to modifications of locality and periods of time, is capable of producing a variety of lesions of the cornea. The cases described, rare as they may be, are not mere coincidences but give proof to the theory that superficial punctate keratitis and its grosser forms, and dendritic corneal ulcer are due to an infection that may also produce herpes simplex. Discussion is amplified under the headings of experimental work, pathogenesis, etiology, symptoms and signs. (References.)

D. F. Harbridge.

Nizetic, Zdravko. **Possibilities and difficulties of keratoplasty.** Klinika Oczna, 1937, v. 15, pt. 1, p. 16.

A review of the literature and a tabulated report of 39 cases. The tables show good results in uncomplicated corneal opacities and poor results in cases complicated by uveitis.

Ray K. Daily.

Pillat, A. **Participation of the cornea in eczema of the skin.** Wiener klin. Woch., 1937, v. 50, May 22, pp. 768-770.

Participation of the cornea in eczema of the face is frequent, and characteristic enough to be spoken of as a clinical entity, for which the author proposes the name of "eczema corneae" or "keratitis eczematodes." The subjective symptoms of such a corneal affection consist of itching and burning of the eyes. The objective findings frequently consist of multiple superficial punctate lesions resembling superficial punctate keratitis, but there is no disturbance of the corneal sensibility. These lesions are very transient and usually appear with acute exacerbations of the skin eczema. In some cases superficial ulcers develop from them, in other cases only punctate areas of hyperkeratosis can be found with the slitlamp. The author suggests that there is possibly a connection between the type of corneal lesion and the type of eczema (eczema maculosum, vesiculosum, pustulosum, or squamosum). Bertha Klien.

Schum, Robert. **A case of bilateral ulcus corneae rodens.** Klin. M. f. Augenh., 1937, v. 98, June, p. 772.

An asthenic man of 35 years suffered from rodent ulcer with extreme pain gradually invading the whole area of both corneae. No remedy was tolerated except panthesin balsam, which gave some relief. After restoration of the epithelium the corneae cleared up to a certain degree with corrected vision of R. 5/12, L. 2/60. Attributing the affection to trophoneurosis with degenerative processes roborant general treatment and blood transfusion were applied. The intense pain was ascribed to exposure of the corneal nerves in the ulcerating process. (Illustrations.)

C. Zimmermann.

Soriano, F. J., and Riva, A. **Scleromalacia perforans.** Arch. de Oft. de Buenos Aires, 1937, v. 12, March, p. 139.

The authors describe bilateral lesions in a female of 56 years, with a history of rheumatism of many years' duration. In the right eye a large upper inner scleral hole close to the limbus, the uvea being exposed peripherally, contained in the center a grayish-yellow plaque suggestive of a sequestrum. The overlying conjunctiva was normal. A smaller lesion existed above temporally. A triangular interstitial vascularized opacity extended into the cornea. Below there was a series of lozenge-shaped depressed lesions at the limbus with normal epithelium. The left eye exhibited lesions in the upper and lower limbus similar to those in the right lower limbus. In addition to the existence of rheumatism, there was a cauda equina syndrome. M. Davidson.

Urrets Zavalia, A., Maldonado Allende, I., and Obregon Oliva, R. **A case of scleromalacia in porphyrinuria.** Arch. de Oft. de Buenos Aires, 1937, v. 12, March, p. 115.

Bilateral, symmetrical, painless holes in the sclera, temporally and within the palpebral fissure, were observed in a male of 67 years, with a history of mild polyarthritis and crops of vesicles with dark-yellow contents on hands. Because of Burgundy-wine color of urine,

porphyrinuria was suspected and demonstrated. The holes were from 4 to 5 mm. in diameter with sharp anterior borders, apparently undermined, exposing the uvea, and posteriorly ending in a greyish plaque with a posterior sharp border suggesting a sequestrum in process of elimination. The overlying conjunctiva was smooth, non-adherent but more vascularized. Transillumination showed thinning of the sclera at site of lesions. In the left eye the plaque could be grasped with forceps and a portion was excised for biopsy, disclosing dense fibrous tissue, suggestive of sclera, without cellular elements. There were evidences of mild uveitis in the left eye, in the form of some deposits on Descemet's membrane, synechiae, and lens-capsule pigment, considered as secondary to the primary scleral disease. Biopsy of the skin lesions was negative as to sclerodermia. Outside the scleral lesions there was a zone of golden-yellow spots involving the adjacent cornea as well. The condition was stationary for one year except for an extension of the lesion in the left eye, and suggestion of the formation of a new lesion in the same eye. The scleral as well as the skin lesions are considered related to the porphyrinuria, which has a light-sensitizing property, but may have other still unknown effects on the human body. (Illustrated.) M. Davidson.

7

UVEAL TRACT, SYMPATHETIC DISEASE, AND AQUEOUS HUMOR

Favaloro, Giuseppe. **A second case of gumma of the choroid.** Rassegna. Ital. d'Ottal., 1936, v. 5, Nov.-Dec., p. 671.

Favalora reports a second case of gumma of the choroid, the first having been reported in 1930. Not more than a dozen such are found in the literature. The patient was a married woman of eighteen years, whose infant was syphilitic. The ophthalmoscope showed slight haziness of the vitreous and in the macular region a tumefaction, two disc diameters in size, irregularly round, yellowish-white in color, exudative, and elevated five diopters. The surface was convex and irregular. The nervehead was hyperemic and the retinal vessels distended. Vision was reduced to counting fingers at 50 cm. Healing was rapid under antiluetic treatment and final vision equalled counting fingers at four meters. The condition is regarded as a tertiary manifestation of lues. (2 figures.)
Eugene M. Blake.

Gardilčić, Ante. **Perineuritis and periarteritis ciliaris in herpes zoster ophthalmicus.** Zeit. f. Augenh., 1937, v. 92, May, p. 35.

To the three cases of involvement of the iris in herpes zoster reported by Meller (see Ophth. Year Book, 1921, v. 17, p. 156, and 1924, v. 20, p. 158) the author adds a fourth from the Meller clinic.

The sections from the eyeball, which had been enucleated because the ulcerated cornea had perforated and vitreous had presented after the prolapsed iris was incised, showed interesting pathologic changes in the posterior segment. Strikingly prominent perineural and periarterial infiltrations with lymphocytes and plasma cells were present. There were intervals with normal arteries and nerves. In the anterior part of the bulbus, the infiltrates became dense and finally disappeared, and therefore, seemed to have no relationship to the purulent corneal process. In the sclera are two areas of necrosis as evidence of the trophic changes called forth by the lesion involving the nerves. F. Herbert Haessler.

Klikova, A. L. **Iridectomy and traumatism to the lens.** Viestnik Opht., 1937, v. 10, pt. 3, p. 413.

In order to demonstrate the relation between iridectomy and subsequent cataract development, 46 excised iris sections were studied microscopically. In each of two sections a segment of the lens capsule was found. One was from a case of occlusion and seclusion of the pupil, and injury to the lens was unavoidable. The other segment was from a case of combined extraction of intumescent cataract, and was found in an atrophic fold of the iris. The author

concludes that cataract following iridectomy is due to faulty technique.

Ray K. Daily.

Polliot, Besançon. **Floating bodies in the anterior chamber, moving under the influence of the accommodation.** Bull. Soc. Franç. d'Opht., 1936, v. 49, pp. 115-122.

Forward movements of strands of fibrin and remnants of pupillary membrane were observed in accommodation for near in three cases, one of traumatic iridodialysis, one of congenital coloboma of the iris, and one of iridocyclitis; while in the fourth, a case of myopia, there were no such movements. The author concludes that the condition was due to currents set up by the bulging of the anterior lens surface during the act of accommodation. The currents were quite noticeable in the presence of a coloboma, being absent when the iris was intact. Such currents set up in the anterior chamber immediately after iridectomy may have some value therapeutically.

Clarence W. Rainey.

Schley, H. **On the value of roentgen ray examination of the vertebral column in diseases of the iris.** Klin. M. f. Augenh., 1937, v. 98, June, p. 780.

Roentgen-ray examination in 105 cases showed with absolute regularity no changes of the vertebral column in tuberculous and luetic inflammations of the iris. Out of 73 cases of superficial iritis, which from the general examination, the clinical aspect, and the therapeutic results from salicylic acid and other anti-rheumatic remedies were considered as true rheumatic inflammations, 10 patients presented spondylitis ankylopoetica, 40 spondylitis deformans and 23 no alteration of the vertebral column. Four clinical histories are given in detail. According to statistics prepared by Junghanns, spondylitis deformans is equally frequent in men and women. In the fiftieth year of life about eighty percent of all men and sixty percent of all women, and after the age of seventy more than ninety percent of all humans have spondylitis deformans. If spondylitis deformans is justly conceived as a degenerative joint disease from wear and tear of daily use, the condition of the vertebral column in simultaneous iritis must be considered as incidental. According to Krebs, cases of spondylitis deformans of inflammatory origin may occur if the settling time of the red blood corpuscles is increased. This was not observed in any of Schley's cases of spondylitis deformans. (Illustrations.)

C. Zimmermann.

Stasinska, Janina. **Latent diabetes and sympathetic ophthalmia.** Klinika Oczna, 1937, v. 15, pt. 1, p. 13.

A report of a case with clinical symptoms and histologic findings in the enucleated eye justifying a diagnosis of sympathetic ophthalmia. Insulin therapy subsequent to the discovery of a high blood sugar led to rapid recovery of the sympathizing eye.

Ray K. Daily.

8

GLAUCOMA AND OCULAR TENSION

Avgushevich, P. L. **The rôle of tonometry in differential diagnosis of the various forms of glaucoma.** Viestnik Opht., 1937, v. 10, pt. 4, p. 580.

A study of the glaucoma curves of thirty patients with various types of glaucoma. The charts show characteristic curves for each form of glaucoma. The curves also demonstrate the action of miotics in prodromal and chronic inflammatory glaucoma, and their ineffectiveness in simple and chronic glaucoma. The study fails to confirm Birch-Hirschfeld's contention that measures affecting the tension of one eye affect also the tension of the other eye.

Ray K. Daily.

Jankevich, E. F. **The oculocardiac reflex in cataract and glaucoma.** Viestnik Opht., 1937, v. 10, pt. 3, p. 397.

One hundred and twenty glaucoma patients and 71 patients with cataract were examined for the Aschner-Dagnini reflex with the object of demonstrating the participation of the vegetative nervous system in these diseases. The technique consisted in subjecting the eyeball to a pressure of 40, 80, and

120 mm. Hg and checking the effect of the pressure on the pulse rate. The tabulated findings show a greater frequency of positive reflex in older persons, which probably has some relation to the blood pressure. The frequency of the reflex rises with the ocular tension, and is most pronounced in absolute glaucoma. In cataract cases the reflex can be elicited but rarely, and then it is usually in the incipient type.

Ray K. Daily.

Streiff, E. B. **The action of syntropan in normal and glaucomatous eyes.** Klin. M. f. Augenh., 1937, v. 98, April, p. 504. (See section 1, General methods of diagnosis.)

9

CRYSTALLINE LENS

Field, J., 2, Tainter, E. G., Martin, A. W., and Belding, H. S. **Studies on the oxygen consumption of the rabbit lens and the effect of 2-4 dinitrophenol thereon.** Amer. Jour. Ophth., 1937, Aug., p. 779.

Fralick, F. B. **Luxation of lens through a retinal tear into the subretinal space.** Amer. Jour. Ophth., 1937, v. 20, Aug., pp. 795-796.

Jankevich, E. F. **The oculocardiac reflex in cataract and glaucoma.** Viestnik Opht., 1937, v. 10, pt. 3, p. 397. (See Section 8, Glaucoma and ocular tension.)

Kiss, Walter. **Visual acuity after bilateral cataract extraction in early childhood.** Klin. M. f. Augenh., 1937, v. 98, April, p. 523.

At the University Eye Clinic of Innsbruck, from 1919 to 1936, 23 children within the first six years of life were operated upon for bilateral cataract, chiefly by primary linear extraction, some by discission. Scarcely one-half of the congenitally blind obtained vision sufficient for school and preparation for work, whereas children who had a certain amount of vision before operation obtained without exception practical sight. The failures in those operated upon under the age of one year were due to complications during operation and course of healing, in the older children to lack of after control due to the peculiarity of the country and poverty of the people. Iridectomy and removal of prolapse within the first year of life proved to be a very serious and dangerous undertaking and confirmed the great vulnerability of the iris in childhood especially emphasized by Elschnig. Clinicians and ophthalmologists must aim at control of patients after operation.

C. Zimmermann.

Klijkova, A. L. **Iridectomy and traumatism to the lens.** Viestnik Opht., 1937, v. 10, pt. 3, p. 413. (See Section 7, Uveal tract, sympathetic disease, and aqueous humor.)

Knapp, H. C. **Spontaneous rupture of the lens capsule in hypermature cataract causing secondary glaucoma.** Amer. Jour. Ophth., 1937, v. 20, Aug., pp. 820-821.

Martín Amat, M. **Mercurochrome sterilization of conjunctiva before and after cataract operation.** Bull. Soc. Franç. d'Opht., 1936, v. 49, pp. 126-132.

Absolute and lasting sterilization of the conjunctiva was obtained by the use of a four-percent aqueous solution of mercurochrome—220. Of 160 cases so treated none was followed by panophthalmitis. Before operation one drop of mercurochrome solution was instilled twice daily. After ten days sterile cultures were obtained. After operation one drop was instilled at the time of the first dressing and once daily thereafter. The only inconvenience was that the mercurochrome solution was irritating to the skin.

Clarence W. Rainey.

Procksch, Marie. **On the prognosis of operation for complicated cataract.** Zeit. f. Augenh., 1937, v. 92, June, p. 129.

One usually underestimates the effect of a corneal opacity on visual acuity and overestimates the effect of a lens opacity. Since the corneal element is often due to astigmatism, a contact glass may be of value in estimating the portion of the disability ascribable to the lens. When the incipient cataract accompanies another ocular lesion, one

must strive to evaluate the quota of the lens in the disability. Patients with opacities in the media usually see relatively much better for near than for distance. While on the whole it takes a visual acuity of 6/24 to enable one to read fluently, a patient with cloudy media may still do so when his acuity has been reduced to 6/60. A stenopeic slit also helps the patient with defective media. Patients with greatly reduced light sense have greatly reduced visual acuity from relatively slight opacities of the media (posterior polar cataract, for example). In retinitis pigmentosa, removal of the most delicate after-cataract is of inestimable benefit. Too small an opening in an after-cataract must be enlarged in retinitis pigmentosa.

F. Herbert Haessler.

Selinger, Elias. **Injection of air into the anterior chamber after cataract extraction.** Amer. Jour. Ophth., 1937, v. 20, Aug., pp. 827-830.

Szafnicki, Marjan. **Operation for secondary cataract.** Klinika Oczna, 1937, v. 15, pt. 1, p. 45.

After a discission with the Galezowski sickle-shaped knife the loose membrane frequently follows the knife into the opening, from where it is extracted with iris forceps. Ray K. Daily.

Szafnicki, Marjan. **The simplest method of cataract extraction.** Klinika Oczna, 1937, v. 15, pt. 1, p. 40.

The poverty-stricken and illiterate population of rural Poland cannot afford time-consuming operations and is content with low visual acuity. The author does a simple extraction and of the modern safeguards uses only retrobulbar injection. Ray K. Daily.

10

RETINA AND VITREOUS

Fuchs, A. **To the clinical significance of circumscribed detachment of the retina at the ora serrata in incipient sarcoma of the choroid.** Klin. M. f. Augenh., 1937, v. 98, May, p. 606. (See Section 15, Tumors.)

Horniker, E. **Remarks as to the article of Sakae Kitahara on clinical observations in serous central chorioretinitis, frequent in Japan.** Klin. M. f. Augenh., 1937, v. 98, April p. 487.

Based on his observations of 18 published and 24 unpublished cases, Horniker discusses Kitahara's views (see Amer. Jour. Ophth., 1937, v. 20, p. 97) and contests the conception of a tuberculous etiology of serous central chorioretinitis. He argues that the disease is not a strictly acknowledged clinical aspect of a uniform etiology, but the expression of a hereditary constitutional peculiarity of the vascular system due to an angioneurotic disposition. C. Zimmermann.

Lisch, K. **Rare forms of tapetoretinal degeneration.** Klin. M. f. Augenh., 1937, v. 98, April, p. 498.

Out of six children of one family four boys in the second decade of life showed impairment of sight, without intense narrowing of the visual fields of two, and with normal periphery in two. Two had central scotoma from marked changes of the macula, in one from hole formation. In all four cases the degenerative changes of the fundus consisted of irregular whitish-gray foci in the retina and irregular accumulations of pigment. Three had atrophic discs and marked invagination streaks of the retinal vessels as after perivasculitis. With one exception the children were intellectually normal and well gifted. The parents were not consanguineous. (Illustrations.) C. Zimmermann.

Mieses-Reif, Maria. **Embolism of the central retinal artery treated with eupaverin.** Klinika Oczna, 1937, v. 15, pt. 1, p. 49.

Eupaverin is a synthetic antispasmodic with the chemical formula of papaverine. The author used it intravenously in two cases with some improvement in vision and visual fields.

Ray K. Daily.

Schmelzer, Hans. **Embolism of the central retinal artery and thromboangiitis obliterans.** Klin. M. f. Augenh., 1937, v. 98, May, p. 630.

While examining at the surgical clinic of the University of Erlangen cases with marked thromboangiitis obliterans of the extremities (so-called

Bürger's disease), Schmelzer encountered a man of 45 years whose left leg had been amputated above the knee on account of gangrene and who presented atrophy of the optic nerve of the right eye after embolism of the central retinal artery. This embolism had suddenly occurred four years previously while the patient was working in the woods. Two years later he had noticed easy fatigue and paresthesia in the left leg. Hence so-called embolism of the central retinal artery or its branches may frequently be an early symptom of a general vascular ailment.

C. Zimmermann.

Tertsch, Rudolf. **Latent holes in the retina within the area of a coloboma of the choroid and traumatic detachment of the retina.** Klin. M. f. Augenh., 1937, v. 98, June, p. 751.

The right eye of a woman of thirty years was struck by a piece of wood which produced a folded detachment of the retina above and extending over the temporal margin of a coloboma of the choroid. The light color of the coloboma was not uniform. It showed a thin yellowish membrane, the rudimentary retina, with several oval holes through which the light bluish-white sclera was visible. The case shows that in congenital hole formations of the retina, latent in the sense of Vogt, detachment may be evoked by traumatism. (Illustrations.)

C. Zimmermann.

Vogt, Alfred. **Histologic findings in a further case of relatively recent spontaneous (senile-myopic) detachment of the retina.** Klin. M. f. Augenh., 1937, v. 98, June, p. 735.

A woman of 72 years, whose left eye had been enucleated two years previously, complained of seeing a shadow in the right eye, which had 11 D. of myopia. After three days ophthalmoscopic examination showed an extensive detachment of the retina with a round hole. A preliminary catholysis was performed. After three weeks the detachment was flatter but the hole still open. The patient died from peritonitis after an operation for purulent cholecystitis, 37 days after onset of the detachment. Thirty minutes after death the eye was enucleated, fixated in formalin, and examined histologically. A detailed description of retina and vitreous is given. The author concludes that the hole formation was due to senile cystic destruction and atrophic attenuation of the retina, and to its connection at the margin of the hole with normal adherent vitreous fibrillae, subject to the "slinging" effect of ocular movements. (Illustrations.)

C. Zimmermann.

11

OPTIC NERVE AND TOXIC AMBLYOPIAS

Adler, F. H. **Bilateral partial colobomata of the optic nerve.** Amer. Jour. Ophth., 1937, v. 20, Aug., pp. 777-778.

Ballenger, H. C., and Johnson, V. H. **Effect on throat and conjunctiva of hygroscopic agent used in cigarettes.** Arch. Otolaryng., 1937, v. 25, Jan., p. 75.

These workers state that the hygroscopic agent used in cigarettes is not a factor of importance in producing symptoms or objective evidence of irritation of the nasal or throat mucosa or of the conjunctival sac. One hundred patients were studied.

Theodore M. Shapira.

Dalsgaard-Nielsen, Esther. **Glaucoma-like cupping of the optic disc and its etiology.** Acta Ophth., 1937, v. 15, pt. 2, p. 151.

A review of the literature and a report of twelve cases of glaucomatous cupping of the optic disc with apparently normal ocular tension. A study of the visual fields and 24-hour tension curves, the water-tolerance test, and X-ray examination of the skull established no etiology in one case, diagnosis of glaucoma in five cases, of glaucoma complicated by vascular lesions in three cases, of pressure atrophy caused by tumor of the brain in two cases, and of congenital malformation in one case. These records demonstrate the great value of perimetry in such cases. The tension curves are less valuable. The water tolerance test is of definite diagnostic assistance. X-ray of

the skull is indicated in difficult cases in order to demonstrate arteriosclerosis of the internal carotid and increased intracranial pressure. (Illustrations.)

Ray K. Daily.

Fuchs, A. **Simple optic atrophy in Recklinghausen's disease.** Wiener klin. Woch., 1937, v. 50, March 5, pp. 291-292.

The optic nerves may be affected in general neurofibromatosis (Recklinghausen) in various ways. Optic neuritis, choked disc, and temporal pallor of the disc may be found associated with exophthalmos. More frequent are papilledema due to intracranial lesions (tumors of the acoustic nerve) and descending optic atrophy due to tumors of the hypophysis. The rarest affection of the optic nerves in Recklinghausen's disease is simple atrophy. The author reports the case of a 37-year-old boxer who had noted failing left vision for four years, and failing right vision for 3½ years. Fundus examination revealed completely atrophic but well defined optic discs. Both temporal halves were very gray, the lamina cribrosa was not visible, the retinal vessels were normal. The Wassermann reaction in blood and liquor was negative and the entire neurologic status was normal. Two small hard subcutaneous nodules, one on the arm and the other on the leg were observed, and a tentative diagnosis of neurofibromatosis with the main location in the optic nerves was made.

Twelve years later the ophthalmologic and neurologic status was unchanged but numerous subcutaneous neurofibromas had appeared and the original diagnosis of Recklinghausen's disease was verified. (References.)

Bertha Klien.

NEWS ITEMS

EDITED BY DR. H. ROMMEL HILDRETH
640 S. Kingshighway, St. Louis

News items should reach the Editor by the twelfth of the month

DEATHS

Dr. Henry Louis Hilgartner, Austin, Texas, died June 9, 1937, aged 68 years.

Dr. Max Lyon Folk, Chicago, died June 7, 1937, aged 47 years (see Obituaries, this issue).

Dr. Frank Aloysius Conlon, Lawrence, Mass., died June 23, 1937, aged 56 years.

MISCELLANEOUS

The following course will be given at the Chicago Eye, Ear, Nose and Throat Hospital, 231 West Washington Street, Chicago, Illinois, from November 1 to November 13, 1937, inclusive.

A. Six-day course (November 1st to 6th inclusive) in surgery of the eye.

B. Six-day course (November 8th to 13th inclusive) in surgery of the ear, nose, and throat. For further particulars write Oscar B. Nugent, M.D., 23 W. Washington Street, Chicago, Illinois.

SOCIETIES

The twenty-second International Medical Assembly, Inter-State Postgraduate Medical Association of North America which meets in St. Louis, Missouri, October 18 to 22, 1937, will have Dr. Alan C. Woods as guest ophthalmologist. The Joseph Schneider Foundation presentation by Dr. Woods will be on the subject, "The problem of ocular tuberculosis." Also, Dr. Woods will be the dinner guest of the St. Louis Ophthalmic Society. On that occasion he will continue his discussion on ocular tuberculosis.

PERSONALS

Dr. R. E. Repass announces the association of Dr. C. S. McLemore in the practice of ophthalmology and otolaryngology, Miami Beach, Florida.

Dr. M. A. Lischkoff announces the association of Dr. N. S. Rubin in the practice of ophthalmology and otolaryngology, 404 Blount Bldg., Pensacola, Florida.

Dr. William P. McGuire, member of the resident staff of the Eye Institute, Columbia University Medical School, New York City, is spending a month visiting the Department of Ophthalmology, Washington University School of Medicine, St. Louis.